A SURVEY OF OLD GROWTH DOUGLAS-FIR STANDS IN THE BIG BELT MOUNTAINS OF MONTANA

by

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A SURVEY OF OLD GROWTH DOUGLAS-FIR STANDS IN THE BIG BELT MOUNTAINS OF MONTANA 1/

by

J. Robert Jansson, Forester, Helena National Forest 2/

INTRODUCTION

This report describes studies designed to learn more than was previously known of the life history of Douglas-fir forests in Central Montana, silvicultural and growth habits of the species, and measures necessary for sound timber management.

Field observations and original data were collected largely on Canyon Ferry Ranger District, Helena National Forest. Investigation also included a review of published literature that dealt with the Douglas-fir type throughout its natural range.

East of the Continental Divide in Montana, Douglas-fir is becoming increasingly important as a source of timber because of shrinking national supplies and increasing demands. This has caused timber operators to turn, more and more, to poorer stands, such as those of Central Montana for raw material.

Douglas-fir forests of the Big Belt Mountains have other values than as sources of wood. They are important for recreation, wildlife, and, above all, as cover for watershed. They retard snow melt, and thus serve to lessen floods and lengthen periods of substantial stream flow. They greatly lessen soil erosion.

1/ A thesis presented to the faculty of the School of Forestry, Montana State University, in partial fulfillment of the requirements for the degree of Master of Science in Forestry, June, 1949.

2/ Data used as a background for this study were secured from numerous sources. The following acknowledgments are made: Stand and stock table data were collected from Forest Service timber surveys. Volume table data were secured from check scale records of government timber sales. Mr. John Casey of the Casey Mining and Equipment Company aided materially in the study of defects with his collection of data on butt rot, windshake, and speck rot. Mr. William Dobler has cooperated on work with insect infestations and aided in securing part of the tree measurement data used in volume table construction. Mr. Floyd C. Hysell cooperated in cull studies by logging cull trees and making it possible to follow logs from stump to sawed material. Mr. L. R. Olson, forester on the Helena National Forest helped gather and check data from local operators. He was responsible for computation of Site IV Douglas-fir volume table with data furnished by the writer. Mr. R. K. LeBarron of the Northern Rocky Mountain Experiment Station gave valuable advice and assistance in preparing the manuscript.

Watershed protection is continually increasing in importance since the Big Belt Mountains of Montana are part of the Missouri River drainage. Located within this mountain area are Holter, Hauser and Canyon Ferry dams. These reservoirs and accompanying power plants furnish irrigation water for the Helena Valley as well as electric power for the Butte, Great Falls, and Helena areas. Today even a larger reservoir and power site is being developed at Canyon Ferry.

When water values are the greatest resource forest land produces, logging should be regulated to the end that a stable permanent water supply is maintained on the watershed area. Since watershed protection in the Big Belt Mountains is increasing in importance, an expanding timber use must leave the watershed values intact.

Timber utilization is also necessary for development preservation of our wood-using industries. Without utilization, a harvest, forestry cannot be practiced. Under the present economic system, forestry on public lands can only be practiced by private enterprise doing the harvesting job. The best way to encourage private enterprise to do the job of harvesting is to assure a continuous backlog of crop material or sustained yield. 3/

The practice of forestry, however, is not the end but a means to an end. The end product is the welfare of the community and nation. Boom and bust industries do not contribute to permanent community or national welfare. It is the job of foresters to establish and maintain timber production on a sound sustained basis consistent with highest principles of watershed management.

It is the purpose of this report to lay the necessary foundation for sound management plans for old growth, even-aged, Douglas-fir, the principal timber stand of the Big Belt Mountains. This is not a final report but the start towards a greater study. Much work needs to be done before we will know all the answers. Specifically, this report compiles by site classes for old-growth, even-aged Douglas-fir, stand and stock tables on an acre basis; defect tables; volume tables; resume of past cutting practices in the area; problem of natural regeneration; and soil types. It deals with a general area description and history as well as the influences which affect the stand.

Work in the management of this timber type by the writer began in 1940. Field work of collecting and assembling data did not begin, however, until 1942. Stand and stock data were secured from Forest Service timber surveys. Only the data of pure, even-aged Douglas-fir stands were selected. Every effort was made to use only verified data. This considerably cut down the number of samples used in the study, but the results are more reliable. Check scaling was done in connection with the data used and check scales are part of official government records. Compression failure and other cull

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3/ All specialized forestry terms, such as 'sustained yield' in this paper are used as defined by: Soc. of Amer. For., <u>Forest Terminology</u>, R. C. Hawley, Ch. Wash., D.C. 1944, 84 pp.

studies were carried on at mill operations by actual mill tally. Surveys, check scales and mill studies were done in the manner prescribed in the "Timber Management Handbook" for Region I of the U. S. Forest Service.

Soil observations and cutover area studies were accomplished in making a "Physiographic Site Survey" of logged areas, mature stands, burned areas and younger stands. This survey is not yet completed, but much of the data was helpful in preparation of this paper.

Office work was done from time to time as surveys and studies were completed. Much of the independent work in connection with this paper has been incorporated into official reports covering timber management activities of the Forest Service.

Since timber stands vary as to quality, size, and volume, data were compiled by "quality site classes." Where possible in check scaling and cull studies data were segregated by site classes.

GENERAL DESCRIPTION OF AREA STUDIED

Location

The Big Belt Mountains of Montana lie between the Missouri and Smith Rivers. The mountain range proper is about 80 miles long and approximately 35 miles wide at the widest part. The area is readily accessible from Helena, Townsend and White Sulphur Springs.

Most of the mountain range is within the boundary of the Helena National Forest. The Big Belt Mountains comprise the Canyon Ferry and the east half of the Townsend Ranger Districts. (Figure 1)

Ownership of Lands Involved

There are about 450,000 acres of land within the National Forest Boundary. About 135,000 acres of this is in private ownership, and the balance is National Forest land. The private land is held by over 100 owners.

There is some forested land in the Big Belt Mountains outside the Forest Boundary. However, little of this outside land contains high quality Douglas-fir logging chances. In this report cuttings on both private land and Forest Service land were included.

Topography

In the geological past the Big Belt Mountains were a part of the Rocky Mountain range. Geological changes have separated the two so that now there is little connection between them. This separation takes place near Wolf Creek, Montana. Geologists estimate

Figure 2. Typical limestone formation in the Big Belt Mountains. Old-growth even-aged Douglas-fir stand covering Sacajawea Mountain, Gates of the Mountain Wild Area.

Figure 3. Upper Trout Creek from Indian Creek. Shows typical topography in the best Douglas-fir logging stands in the Big Belt Mountains.

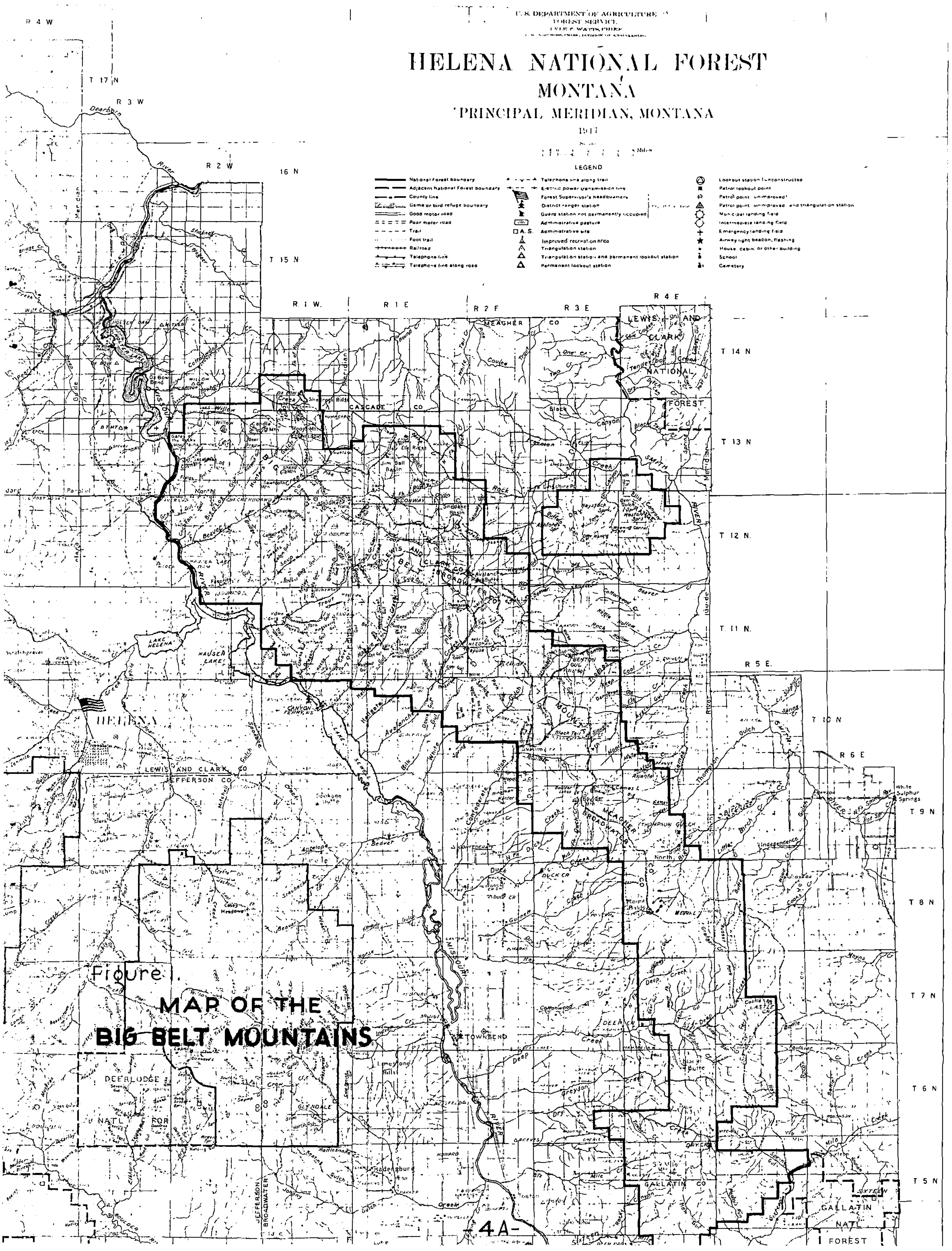

Figure 1. MAP OF THE BIG BELT MOUNTAINS

the erosion on the west side of the Missouri River has progressed about 1500 feet deeper into the earth than on the east side. This can be seen on the west side by the exposed igneous rock formations which lie below the sedimentary limestone seen on the east side.

According to L. F. Gieseker 4/ - "The Big Belt Mountains were formed by a broad, folded arch uplift which has been dissected to produce saw-toothed ridges and deep intervening stream valleys. Rock outcrops are largely Algonkian slates and quartzites with Carboniferous limestones exposed on the west slopes. Intrusive dikes of igneous materials occur in places." Figure 2 pictures a typical limestone outcrop. Minerals are found in these dikes, some portions being rich in gold, silver, lead and copper. It was gold that first brought an influx of white people into the area.

The three main rock formations in the area are: Limestone, shale and diorite. The general topography is extremely rough with many limestone canyons and cliffs. Limestone and granite outcroppings make logging difficult if not impossible in some areas.

Elevations range from 3500 to 9200 feet above sea level. Sheer canyon walls rise 1200 feet from river and creek bottoms. From the divide of the range east there are high mountain meadows and rolling grassy plains such as Jim Ball and Snedaker basins. These are at elevations of 7000 feet and on the west side of the divide break off into creek bottoms of 4000 feet elevation in two miles or less.

Best timber-growing sites are along the Missouri River bench (low hills and basins under 5000 feet) for ponderosa pine (*Pinus ponderosa*) and in the creek bottoms and benches on north and east slopes for Douglas-fir (*Pseudotsuga taxifolia*). A typical Douglas-fir forest is shown in Figure 3.

Climate

The climate varies from semi-arid in the foothills and the intermountain basin (Townsend and Helena valleys) to subhumid in the high mountain areas. The Helena valley annual precipitation based on 64 year average is 12.74 inches per year. The Townsend and Helena valleys are characterized by wide extremes in temperature, a large percentage of sunny days, and a fairly low humidity.

The mean annual precipitation at Canyon Ferry based on 43 years of records by the Montana Power Company is 11.32 inches. The mean annual temperature at the same station is 43.7 degrees with the highest temperature 100 and the lowest -49 degrees. Lowest annual precipitation on record is 6.01 inches, while highest annual precipitation was 16.35 inches. Average annual snowfall is 28.1 inches. Rainfall increases with rise in elevation. Higher mountain areas

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4/ Gieseke, L. F. *The Soils of Broadwater County*, Bul. 241, March 1941, Montana State College Agricultural Experiment Station, Bozeman, Montana.

receive considerably more annual precipitation and a greater amount of snow than Canyon Ferry. Snow is never very deep in Belt mountain areas. Three feet accumulation on the level is a severe snowfall year while the average is about 12 inches.

The rainy season is usually during May and June with additional moisture falling in the late fall and early winter. About 2/3 of the annual precipitation occurs from May through September.

Prevailing winds are from the west and southwest although this may be affected by ridges and canyons. The Townsend area has a northwesterly prevailing wind due to the influence of the Spokane hills and the Elkhorn mountains both on the west side of the Missouri River. Chinook winds occur during the winter months which prevent snow accumulations at lower elevations and settle snow at higher elevations.

Mountain temperatures are not as high during summer nor as low during winter as those recorded at Canyon Ferry. Summer humidity is low so that days are never oppressively warm in the mountains.

The Smith River climate is somewhat more rigorous than the Missouri River side of the range. Smith River receives more precipitation, snows begin there earlier in the fall and thaws start later in the spring than on the lower Missouri side. Summer temperatures are not as high on the east side as the west side.

Soil

Big Belt Mountain soils have not been surveyed as yet although the foothills and some of the benchlands outside the National Forest Boundary have been classified by the Soil Reconnaissance of Montana.

The soils of the mountain range are described in the Yearbook of Agriculture for 1938 5/ as lithosals and shallow soils of arid-subhumid type of climate, belonging to the Underwood-Babb series. These soils are characterized by "a great variety of sedimentary, metamorphic and igneous rock parent material, either in place or in talus slopes, outwashes and terraces." Since none of the area has been mapped the characteristics of the soil are not known in detail. Soils do not exist as large uniform areas but are exceedingly complex. They vary greatly in texture, color, structure, depth, stoniness and relief in short distances. For the most part, they are shallow, stony and lack a definite profile development. Soils on ridge tops and south and west slopes have brown to dark brown or nearly black topsoils and lighter brown subsoils. Soils from a calcareous parent material may have a light grey layer of

5/ Soils & Men, Yearbook of Agriculture 1938 U.S.D.A., Government Printing Office, Washington, D.C. 1938, 1232 pp.

lime concentration in the lower subsoils. This is not typical of larger areas. On the north and east slopes under dense timber stands, the soils below the dark leaf mull are light brown, leached, and similar to those of the Helmer-Benewah-Santa series.

Important Forest Associations

The Big Belt Mountains contain a number of forest associations which are easily recognized, although some are near the limits of their range and consist of only small patches here and there.

Petran Subalpine Forest 6/

Petran Subalpine forest occurs in the area at elevations of 7000 feet and up. According to Weaver and Clements 7/, precipitation requirements of this climax run from 22 to 40 inches per year with 8-14 feet of snowfall. The association occurs on upper east and north slopes where snow drifts deeply during the winter. Only small areas of this association occur. Because of the snowdrifts and dense undergrowth of reproduction, especially of alpine fir, the association is usually considered protection forest and not a logging type. Since this association contains most of the deeply drifted snow and the species habitating the association are mesophytic, these patches might be considered moisture reservoirs and are better left uncut to prevent spring floods and intermittent stream flow later in the summer season.

Important tree species are: alpine fir (Abies lasiocarpa, [Hook.] Nutt.); Engelmann spruce (Picea engelmanni, Parry); lodgepole pine (Pinus contorta, Dougl.); and limber pine (Pinus flexilis, James).

There is a mixed variety of grasses and forbs under the tree canopy. These are various species of columbines (Aquilegia spp.); arnica (Arnica spp.); pine grass (Calamagrostis spp.); Indian paint brush (Castilleja spp.); daisy (Erigeron spp.); strawberry (Fragaria spp.); skunkweeds (Polemonium spp.); goldenrod (Solidago spp.); and meadow-rue (Thalictrum spp.).

In the Belt Mountains at elevations over 7800 feet there occur a few acres here and there of subalpine association closely resembling in composition the Sierran subalpine forest.

The north slope of Hogback mountain is one of the best examples observed. Here the snow is blown off a mile stretch of ridge top and deposited in deep drifts in an area about 15 acres. The association is well protected from the drying effects of winds.

6/ Petran refers to the Rocky Mountain formation.

7/ Weaver, John E. & Clements, Frederic E., Plant Ecology, 1938, New York: McGraw Hill Book Company, 601 pp.

Tree species are _Pinus flexilis_, _Pinus contorta_ and _Abies lasiocarpa_.

One interesting feature of this formation is the blending of a xerophytic type abruptly into it. This is the result of snowfall being swept from one side of the mountain and being deposited on the other. The dry windswept ridge has a stand of juniper and xerophytic grasses and weeds.

Petran Montane Forest

Petran Montane forest has its widest contact with subalpine formation at Montane upper elevations. At lower elevations it touches grassland on east slopes.

Rainfall limits are 18-20 inches at lower limit to 22-to 23 inches at the upper margin. Although scattered forest stands of poorer quality are found at lower precipitation averages.

Principal tree species found in this association in the Belts are: Douglas-fir (_Pseudotsuga taxifolia_, var. _glauca_ /_Mayr_/ Sudw.); ponderosa pine (_Pinus ponderosa_ Dougl.); and lodgepole pine (_Pinus contorta_). At higher elevations these mix into the subalpine with the exception of ponderosa pine.

Shrubs and trees found in this association are: ninebark (Opulaster spp); wild rose (_Rosa_ spp.); currant (_Ribes_ spp.); together with scattered aspen and cottonwoods (_Populus_ spp.) and willows (_Salix_ spp.).

Weeds and browse plants consist of geranium (_Geranium_ spp.) Indian paint brush (Castilleja spp.); daisy (_Erigeron_ spp.); goldenrod (_Solidago_ spp.); columbine (_Aquilegia_ spp.); violet (_Viola_ (Viola spp.); virgins bower (_Clematis_ spp.); and strawberry (_Fragaria_ spp.). There are many other species of lesser importance.

Grasses and grasslike plants occur in great variety. The principal ones are: sedge (_Carex_ spp.); pine grass (_Calamagrostis_ spp.); brome grass (_Bromus_ spp.); wheatgrasses (_Agropyron_ spp.); fescues (_Festuca_ spp.); and blue grasses (_Poa_ spp.). With the exception of pine grass most grasses are found in open parks or open tree stands.

Timber Types

Pure timber types in the Belts according to their importance are: Douglas-fir, lodgepole pine, and ponderosa pine.

Intermixtures of these occur and the following subtypes are recognized: Douglas-fir-lodgepole; ponderosa pine-Douglas-fir; ponderosa pine-juniper; and spruce-Douglas-fir or combinations of this type when coming in contact with the Petran subalpine forest.

Douglas-fir is the principal timber producing tree and it is the pure even-aged stands of this species with which this paper is primarily concerned.

Local History

The first information regarding the Belt Mountains is found in the diaries of members of the Lewis and Clark expedition through the Northwest in 1805 and 1806. Captain Meriwether Lewis camped at what is now called Meriwether Canyon in the Belt Mountains (some students of the Lewis and Clark expedition claim the campground was in Coulter Gulch, the next gulch up river) on his journey up the Missouri River. He also gave the name "Gates of the Rocky Mountains" to the Missouri River Canyon in the north end of the Belts. This is an unusual scenic canyon which today many tourists enjoy by taking an excursion boat down river to visit Meriwether Canyon. The name "Gates of the Mountains" was applied by Captain Lewis to the limestone formations which jut out into the river giving the illusion of gates opening as one travels up the river by boat.

The intermountain region between the Belts and the Rocky Mountains was the hunting ground of the Blackfeet, Crow and other Indian tribes. These tribes were placed on reservations during the 1880's. Trapping and trading with the Indians were the chief occupations of the white man immediately following the Lewis and Clark expedition.

Gold was discovered in the Big Belt Mountains in 1864 and 1865, which precipitated local gold rushes. Most famous of the placer diggings was in confederate Gulch at Diamond City. Here Montana Bar was proclaimed the richest ground in the world. Over one million dollars of gold was removed from one acre of ground.

The Belt Mountains are marked with old diggings and settlements such as Nelson, York (called New York in the early days), Jimtown, Whites City, and Diamond City. Silver and lead ores were discovered shortly after the big gold strikes.

In 1883 the Northern Pacific railroad was constructed through the area. For a few years ores from mines in the Big Belt, Elkhorn and Castles Mountains were transported to Toston and smelted. Later the East Helena smelter was established and ores are now shipped there.

Stockmen brought their herds into the area from western Montana. Later after military forts were constructed, such as Fort Logan on the Smith River, cattle were brought in from Kansas and Texas. Some stockmen established ranches on stream valleys suitable for hay production and on land where water holes were available.

In the 1870's the north end of the Belts was penetrated by settlers. The chief occupations were logging and mining. The town of Great Falls which had been started on the plains to the north was growing rapidly. The demand for timber for town building and mining was great. Helena, too, was becoming well established and

was soon to become the state capital.

Logging operations covered the entire ponderosa pine area on the west slope of the Belts. Logs were floated down the Missouri River to sawmills in Great Falls. Some local mills were set up at Nelson, York and Cave (Canyon Ferry).

Logging was selective and heavy. The early-day loggers worked areas which no one would be interested in today. Slopes were steep and topography rugged, but man-power was cheap. Logs were hand-skidded to flumes and chutes and sent into the Missouri River and driven downstream. The American Logging Company was one of the principal early operators.

After the stands were cut-over, slash left on the ground became ignited, probably by lightning since this is a lightning belt. For the most part the ponderosa pine belt was burned over in the late 80's and early 90's. Today much of the ponderosa pine belt is in a poorly-stocked and decadent condition. It will be many years before the area can be extensively cut over again.

After the collapse of the lumber industry, and most of the good placer diggings had been worked by the methods available at that time, many of the early settlers turned to stock raising. Some of their descendents are still living and operating ranches in the area today.

The mining boom collapse shut down small mills working in the Douglas-fir type back in the mountains. Since many of the drainages appeared inaccessible, logging as an industry also collapsed. A few mills continued to operate from time to time as local gulches were worked by local mining activity.

In the last of the 1890's and the first part of the 1900's, Holter, Hauser and Canyon Ferry dams were constructed. This called for much piling and rough lumber. The ponderosa pine bench was reworked again around Hauser and Canyon Ferry dams. Favorite Gulch and Magpie Gulches were cut over, the latter only partially.

In 1905 the Helena National Forest was set aside by Presidential proclamation. Fire protection and timber management were instituted. Since the ponderosa pine was gone and Pacific coast areas contained such superior Douglas-fir the timber resources of the Belts were not considered great. Management of the forest was concerned more with fire protection, grazing and special-use areas than with timber management.

About 1906 a dry-land farming boom started in the area and by 1915 all the more desirable range lands or cleared areas were homesteaded. This again exerted some local pressure for houselogs, rough lumber and farm wood products.

By 1921 drought conditions convinced many of the homesteaders dry-land farming was not suited to much of the homestead areas and some were abandoned; others are still held but used as range lands only. Population decreased after the drought.

In the depression era gold was revaluated and interest in mining again boomed especially among the unemployed. Many amateur prospectors moved into the hills to grub out two or three dollars a day by reworking old diggings or staking new claims. Mines unprofitable under the old price of gold again became profitable. The Golden Messenger Mine at York resumed operation employing up to 50 men. Many families moved into the York community again. Gold dredges were brought into Eldorado Bar and Confederate Gulch.

Renewal of gold mining stimulated a local demand for structural timber. By 1936 several small mills were in operation cutting mine timbers and rough boards.

With the advent of World War II mining ceased because "priorities" for mining gold could not be obtained. High wages were being offered in war industries. Miners as well as woods workers migrated to the defense industries.

About half the small mills ceased to operate because of high labor costs, scarcity of equipment, and labor. But by the end of 1943 the lumber needs of the nation had become so critical that several ranchers got out their old mills and began to cut a few thousand feet a year during the winter time to augment their incomes.

With the close of World War II demand increased for lodgepole pine to be used as power poles and pulp. The expanding national industrial activity required more wood products of all types. It is now possible to establish a local woods industry which can consume the sustained timber yield of the Belt Mountains.

DESCRIPTION OF PURE OLD-GROWTH DOUGLAS-FIR TYPE

As nearly as can be determined the present old-growth stands of pure Douglas-fir are the result of reproduction coming in after a fire, or series of fires, which swept the range about 260 years ago killing the existing stands of timber. Age of trees in the stands studied was from 220 to 260 years old with occasional old wolf trees of greater age left from the previous generation. These pure even-aged stands of Douglas-fir are now overmature. There have been more recent fires which have given rise to other even-aged stands in the younger age classes.

Some areas were not entirely wiped out by the fire 260 years ago and areas remained which later died out. This has produced stands in which the timber is two or more storied. Other stands were wiped out. Subsequent reproduction suffered other disasters which cleaned out patches here and there. These stands also have a storied appearance. One or two stands are actually so mixed in age that they can be called uneven-aged.

There are other areas recently burned which have not reproduced, or are just now reproducing, so that a full range of stand conditions and age classes exist in the area.

Definition of Term 'Site Class'

Foresters ordinarily express relative productivity of different areas for timber production in terms of site quality. Site quality is defined as the height attained by dominant and codominant trees in a stated number of years. For sake of convenience, the total range of possible heights for a species at any given age is arbitrarily divided into several classes. In the use of Douglas-fir, the United States Forest Service has recognized six site classes. Height is given by ten-year age classes for each site. (See Forest Service Form M-1027-R-1 in appendix)

To be classed as Site I, the dominant and co-dominant trees in a stand must have a total height of 220 feet. A site class of II at the same age must have dominants and co-dominants averaging less than 220 feet but more than 184 feet. A site III must have dominants and co-dominants at least 149 feet tall and so on. This classification may not be wholly reliable because it is not certain that stands of different ages have been consistently related to the proper site classification. However, it is the only classification available for Douglas-fir. Hence, we are forced to use it until such time as the table can be confirmed or adjusted.

Mature stands are classed according to number of merchantable 16-foot logs in the dominant trees. There is little doubt as to the site class a stand should be given at maturity. Since this paper deals only with old-growth even-aged stands, the merchantable log height is a reliable index.

The Big Belt Mountains contain three classes of site. These are sites IV, V and VI. Site IV (Figures 4 & 5) includes stands whose dominants are 5-7 merchantable logs high. Site V dominants are 3-4 merchantable logs high. Site VI has 1 to 2 logs. Site VI is of such poor quality and low volume as to be unmerchantable.

A merchantable log is 16.3 feet long and must be at least 8 inches d.i.b. (diameter inside bark). A site class may have trees smaller or larger than the standards set up. The classification is based on the average.

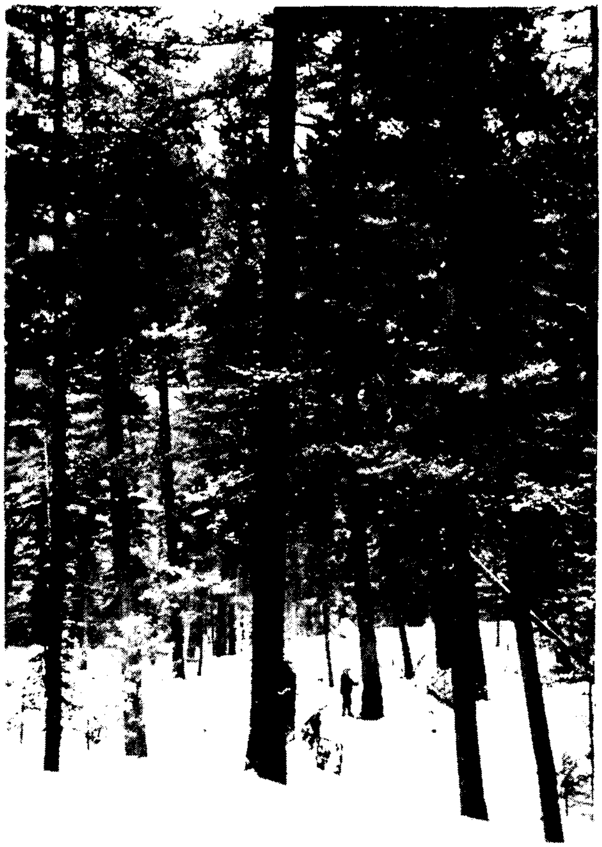

Figure 4. Site IV Douglas-fir stand, Indian Creek, elevation 5800 feet above sea level.

Note absence of vigorous advanced reproduction in foreground. This is typical of these stands. Age of stand 260 years.

Figure 5. Hidden Valley, Site IV Douglas-fir.

Advanced reproduction, 21-40 year age class, present in crown opening.

In determining boundaries of each site class no effort is made to distinguish local changes in site. Every site IV will have local spots of a few acres where the dominants are 3-4 logs high. Occasionally an eight-log tree may occur. Likewise site V will have a few 5 log trees or even larger. To attempt to break the classification down to specific occurrence would make the surveys complicated and cumbersome. Therefore, a change in site class is not recorded if less than 5 acres and usually not any smaller than 10 acres.

About 77 percent of all old growth Douglas-fir stands in the Belts fall into site class VI or protection forest. About 30% of the remainder or 7% of the whole is site IV. The balance or 16% is site V.

Changes in site class were found to be due to any one or a combination of the following: differences in elevation, differences in soil, differences in slope and exposure and sometimes because of other differences in local climate.

Since only sites IV and V contain merchantable timber, this study has been confined to these two classes. For each class a stand and stock table for an average acre has been compiled. Also a cull tree table, volume table and a soil profile description. Each site will be discussed separately.

Site Class IV

The majority of site IV stands occur at elevations ranging from 5000 to 6800 feet above sea level. These stands are usually confined to creek bottoms and benches on north and east slopes where the soil shows definite profile development.

A stand and stock table for an average acre of Site IV timber is given in Table 1, for the total stand. It was compiled by averaging the acceptable survey data for all site IV sample plots. 277 one-tenth acre plots were used along with 44 one-fifth acre plots, making a total of 36.5 acres sampled.

Table 2 includes the visibly 8/ defective trees tallied during the survey and must be deducted from Table 1 to give the average net volumes found in site IV stands. This is done in Table 3. Visibly defective trees are those trees which are determined to be 50% or more defective at the time of survey. Trees of this type cannot be removed by the operator except at a loss.

Table 3 gives the percentage loss in "invisible" defects not determined by eliminating the whole tree during sampling. Net volumes of merchantable stumpage may be determined for an average acre by reducing the volume in Table 4 by the percent defect in Table 3.

8/ Visible defects were punk knots, conks, excessively limby trees, excessively crooked trees and trees which were obviously dying.

Table 1.

Total Stand & Stock Table of Trees 10 Inches d.b.h. and Larger for an Average Acre of Site IV Douglas-fir in the Big Belt Mountains of Montana 1/

D.B.H. o.b.	Av. No. 2/ 16-ft. logs	Av. Vol. per Tree (Scribner D.C)	Logs per M.	Trees per M.	Trees per acre	Basal Area	Vol. per Diam. Class	Vol/s.f. B. A.	Total Vol. per Acre (Scribner)
Inches	Number	Bd. Ft.	Number	Number	Number	Sq. Ft.	Percent	Bd. Ft.	Bd. Ft.
10	1.25	4	31.2	25.00	5.38	2.96	.9	9	21
12	2.00	8	25.0	12.50	6.18	4.88	2.2	10	49
14	2.70	13	20.8	7.69	11.15	11.92	6.5	12	145
16	3.71	26	13.9	3.84	12.09	16.91	14.1	19	314
18	4.14	35	11.8	2.86	9.22	16.30	14.5	20	322
20	4.59	45	10.2	2.22	8.04	17.51	16.4	21	364
22	4.62	55	8.3	1.82	3.63	9.59	8.8	20	196
24	4.87	69	7.1	1.45	3.76	11.82	11.7	22	259
26	4.86	77	6.3	1.30	2.45	8.80	8.5	21	189
28	4.76	89	5.4	1.12	1.21	5.18	4.9	21	108
30	5.06	109	4.6	.92	.51	2.52	2.6	22	56
32	5.05	122	4.1	.82	.43	2.40	2.5	22	52
34	4.79	128	3.7	.78	.14	.87	.8	20	18
36	4.76	141	3.4	.71	.37	2.62	2.3	20	52
38	5.27	179	2.9	.56	.11	.87	.9	23	20
40	4.70	170	2.8	.59	.10	.87	.8	19	17
44	5.00	220	2.4	.45	.03	.32	.3	21	7
46	5.00	240	2.1	.42	.05	.58	.5	21	12
52	5.00	300	1.7	.33	.03	.44	.4	20	9
54	5.00	330	1.5	.30	.03	.48	.2	21	10
Av. 17.4	3.11	34	9.17	2.95				19	
Total					64.91	117.84	100.0		2220

1/ Basis--10-14 inches D. B. H. based on 277, tenth-acre plots. Other diameters on 277, tenth-acre plots and 44, fifth-acre plots.

2/ Minimum merchantable log 8" d.i.b., each log includes .3 foot trim allowance and is 16.3 feet long.

Table 2

Cull Trees in Average Acre of Site IV Douglas-fir Big Belts

D.B.H. o.b.	Trees per Acre	Volume per Acre (Scribner Dec. C)	Basal Area	Percent of Volume *
Inches	Number	Bd. Ft.	Sq. Ft.	
10	.21	1	.12	
12	.23	2	.18	
14	.43	6	.46	
16	.52	14	.73	
18	1.26	44	2.23	
20	.84	38	1.83	
22	.34	19	.92	
24	.21	14	.66	
26	.15	12	.55	
28	.08	7	.34	
30	–	–	–	
32	.05	6	.28	
34	–	–	–	
36	.08	11	.57	
38	–	–	–	
Totals	4.40	174	8.87	7.8%

*Percent of Volume in Table I

Based on 277 1/10 acre plots

Cull Tree: 50% or more of the volume defective as estimated by timber cruiser at time of survey.

Table 3.

Defect Analysis Sites IV and V.

Defect	Length of Tree	Amount of defect	Infected trees	Trees in sample	Volume in sample	Occur. based on scale	Causative Agency
		Bd. Ft.	Number	Number	Bd. Ft.	Percent	
Speck rot	100%	8660	23	492	169,780	5.1	*Fomes pini*
Butt rots	6.26 ft.	4880	100	492	169,780	2.9	*Polyporus schweinitzii* *Fomes laricis* *Polyporus sulphureus*
Crook, catfaces, sweep & other	–	470	27	90	45,550	1.0	Fire & natural growth
Wind shake & compression failure, frost	–	2450	15	498	175,000	1.5 (.8*)	Wind, falling frost
Breakage	–	410	16	51	25,050	1.6	Logging
Total Defect						12.0%	

* .8% of defect could be traced to wind and .6% to compression failures due to falling.

From Tables 2 and 7
Site IV cull 7.8% plus 12.0% equals 19.8%.
Site V cull 16.2% plus 12.0% equals 28.2%.

Table 4.

Merchantable Stand and Stock Table for an Average Acre of Site IV
Douglas-fir in the Big Belt Mountains
(Table 1, minus Table 2)

D. B. H. o. b.	Trees per Acre	Basal Area	Volume (Scribner D. C.)
Inches	Number	Sq. Ft.	Bd. Ft.
10	5.17	2.84	20
12	5.95	4.70	47
14	10.72	11.46	139
16	11.57	16.18	300
18	7.96	14.07	278
20	7.20	15.64	326
22	3.29	8.67	177
24	3.55	11.16	245
26	2.30	8.25	177
28	1.13	4.84	101
30	.51	2.52	56
32	.38	2.12	46
34	.14	.87	18
36	.29	2.05	41
38	.11	.87	9
40	.10	.87	17
42	–	–	–
44	.03	.32	7
46	.05	.58	12
48	–	–	–
50	–	–	–
52	.03	.44	9
54	.03	.48	10
Totals	60.51	108.89	2046

Speck rot (Fomes pini) is an extremely variable factor and should be determined for each area. Its occurrence has been found to run from a negligible amount to as high as 70% of the stand volume.

Trees below 10 inches d.b.h. (diameter breast high, outside bark, a point 4.5 feet from the ground) were eliminated from the data for the following reasons: At the present time Douglas-fir is being cut primarily for sawlogs. A tree 10 inches d.b.h. is the smallest tree containing one merchantable log. Trees below 10 inches may be of a different age class due to advanced reproduction in crown openings or under the old crown under favorable conditions. Trees below 10 inches of 200 plus years of age are usually badly stagnated and dying. Mortality rate of badly suppressed trees after logging is high. Trees below this size in the original survey either were not tallied or were not separated by species or age class so that for this paper the data were thought to be of doubtful value and were eliminated.

Table 5 is a local volume table for site IV Douglas-fir. It is a correction of an alignment chart table in the Timber Management Handbook of Region 1, U.S.F.S. 9/ Sixty-two trees were measured on the ground for correcting this table. Data were collected from Whites Gulch and Trout Creek areas and were from site IV trees.

Soil Profile Description - Site IV

Described below is the most common type of profile developed in the Belts where the drainage is good, where there is no accumulation of soil deposits from accelerated erosion, where the understory contains a large amount of shrubs, forbs and grasses. The soils tend to be podzolic. Where the upper horizons are acid, the horizon colors are usually in the dark brown-yellowish range. On neutral or alkaline soils the soil colors are black-grey-whitish. Most site IV soils are acid in the A horizon, becoming highly alkaline in the lower strata either from deposition or from the parent material. Soils have overlapping horizons making it difficult to distinguish sub-horizons. In some cases the A_2 horizon may not be well developed. A_3 and B_1 horizons are too overlapping to be distinguished.

9/ A complete report on the calculations is filed with the Forest Service at Canyon Ferry Ranger Station - S - STUDIES - Volume Tables - Douglas-fir, A Volume Table Applicable to the Belt Mountains, July 8, 1948.

Table 5

BIG BELT MTN DOUGLAS-FIR BOARD FOOT VOLUME TABLE - SITE CLASS IV

(Scribner Decimal C)

D.B.H. o.b.	Height in Merchantable Logs to an 8" top d.i.b. 2	3	4	5	6	7
10	7	12				
12	8	13				
14	10	16				
16	11	20	28	37	45	
18	12	23	33	44	54	
20	14	26	39	51	64	
22	16	31	45	61	77	
24	18	36	53	72	90	110
26	20	41	60	82	102	125
28	24	46	68	94	120	145
30	27	51	78	107	137	165
32		57	88	120	155	185
34		64	98	135	175	210
36		72	110	150	195	235
38		79	120	165	215	260
40		86	135	185	235	285
42		94	145	200	260	310
44		102	160	220	280	340
46		112	175	240	305	370
48		120	185	260	335	400
50		130	200	280	360	440

Corrected by the alignment chart method from table in Timber Management Handbook for Region I by U. S. F. S.

62 sample trees used in correction.

Original table prepared by alignment chart method. Stump height 1.5 feet. No allowance for defect. Basis 406 trees actual volume 1.3 percent above estimated volume.

Horizon	Thickness	Description
A_{oo}	1-2"	Loose litter varying by location in depth. Litter composed of twigs, needles, cones, dead herbaceous vegetation, etc.
A_o	½-1"	Fermenting litter usually quite compact but signs of original organic structure still existing.
A_1	½-2"	Black or deep chocolate-brown mixture of acid humus and mineral soil; high degree of organic matter.
A_2	1-4"	Light tan to greyish white leached area sandy to silty. Sometimes not well developed.
B_2	4-8"	Yellow tan to light brown but darker than A_2. Appears to have more organic contents and iron oxides than A_2. Sometimes has accumulation of clay. Usually stony at lower end.
C	6-24"	If limestone parent material will be grey to a tinged tan or yellow color. If from igneous parent material usually light brown or in cases of heavy mineral content (iron) may be reddish. In grey soils a high degree of carbonate accumulations. Sometimes very stony.
D	—	Usually carboniferous limestones.

In cases where much silt has been deposited from past accelerated erosion now stabilized because of ground cover, a different type of profile has developed.

In this case 2 or 3 feet of top soil below the A_{oo} and A_o layers may be black in appearance partially resembling a half bog type profile. Black layer extends to the B_2 horizon which is light to medium brown. Mixed through the first few feet of the black soil will be found charred bits of wood and other debris which have been found as deep as 2.4 feet. This leads to the theory that the stand originally was clean burned, resulting erosion deposited silt in the hollows and small basin-like areas which are poorly drained. Shrubs became established on the new deposit and finally tree reproduction was established. Top soil tests neutral in some cases. At about one foot the soil becomes distinctly acid which in part may be due to poor drainage. Tree growth, as tested by increment borings, appears to be rapid on this type of soil.

In part this may be due to poorer drainage making more available tree moisture. Acid soils appear to favor rapid growth of Douglas-fir.

Reproduction

Healthy reproduction in site IV stands is almost lacking. Some areas, for instance Indian Creek bottom, have such poor advanced reproduction that it is doubtful if the trees will survive rigors of logging and exposure which results from removal of the over story. Some will never respond to release. Trees 2 inches d.b.h. have been examined where the rings were so close together that counting even with a hand lens was impossible. Larger trees below 10 inches d.b.h. in the vicinity were found to be 260 years old, and it is assumed that these suppressed trees were near that age. Many are infected with Fomes pini so that even if release were obtained no sound increment would be gained.

Where the stand is more open, advanced reproduction of younger age classes occurs. This is especially true where original members of the stand have died and made room. For the most part, in site IV stands good reproduction is not present. If regeneration is to be obtained after logging, cut-over areas must be planted or cutting must be heavy enough to open up the canopy sufficiently to start natural reproduction.

Seed, of course, is an essential requirement. Some observations suggest that overmature Douglas-fir trees of this mountain range are poor seed producers. Until this point is settled, there will be uncertainty as to whether natural reseeding can be relied upon.

Reproduction after logging will be discussed further in chapters entitled "Effects of Past Cutting Practices" and "Reproduction."

Site Class V

Compilation of site class V data (see Figures 6 & 7 for site V stand) was done in the same manner as compilation of site class IV. 353 one-tenth acre sample plots and 249 one-fifth acre sample plots were used, making a total of 85.1 acres sampled. Data from these plots are the basis for Table 6.

Table 7 is the total stand and stock table for an average acre of site V Douglas-fir in the Big Belt Mountains.

Table 8 includes visibly defective trees tallied during the survey and must be deducted from Table 7 to give the average net volume per acre. Table 9 is the net volume per acre when trees visibly 50% or more defective are eliminated. To determine the net volume of merchantable stumpage, Table 9 volume must be reduced by the average percent defect as given in Table 3.

Table 10 is the volume table for site V timber. It is a 5% reduction of volume table for site IV as given in Table 5. Table 6 gives the basis for making this 5% reduction in site V timber over site IV. This difference is due to differences in form of trees from the two sites.

Table 6. Volume Table check by Site Classes

Area Sampled	Site Class	+ or − Volume Table: Site IV	Amount of Sample	Average for Site Class
Spring Gulch	IV	− .4%	5440 bd. ft.	
Indian Creek	IV	+1.3%	11290 bd. ft.	−.5%
Indian & Trout	V	−4.9%	26710 bd. ft.	−4.9%

Measurements are in addition to those incorporated in the adjusted volume table. In all, 102 trees containing 43,440 bd. ft. were used in checking accuracy of Table 5.

Soil Profile Description - Site V

Better site V soils show zonation in profiles and are similar to site IV profile previously described. Soils are shallower and, in some cases, may not have progressed quite as far towards podzolization.

The poorer site V stands occur on a variety of lithosols which vary greatly in texture, color, structure, depth, stoniness and relief in short distances. Color of the sub-soil apparently is related to the parent rock material. Red soils are common on certain types of porphyry and spokane shale parent rock. Empire shales (green)and other shales have a grey-green to yellow-brown sub-soil that varies from two or three inches to about a foot deep. A greyish sub-soil develops over limestone formations. The component parts of what normally would be termed the A horizon vary from less than one inch to about two inches. Deeper soils usually began to show profile development and leaching. The true lithosol is a raw soil. Why the soils do not seem to have the depth or development is in part due to erosion and lack of deposition from above. Site V soils are usually side hills, raw stream bottoms and undeveloped or badly disturbed soils. In substance they are soils which have not fully developed because of unfavorable topographic position, constant disturbing influences such as recurrent fires accompanied by erosion, bad cutting practices, or fast natural erosion.

Sub-soils are usually stony with silt or clay particles interspersed between the larger aggregates. Only the better site V soils which exhibit profile development have an acid top soil. The true lithosol has little organic content in the upper strata and has an alkaline reaction or at least neutral, a fact which

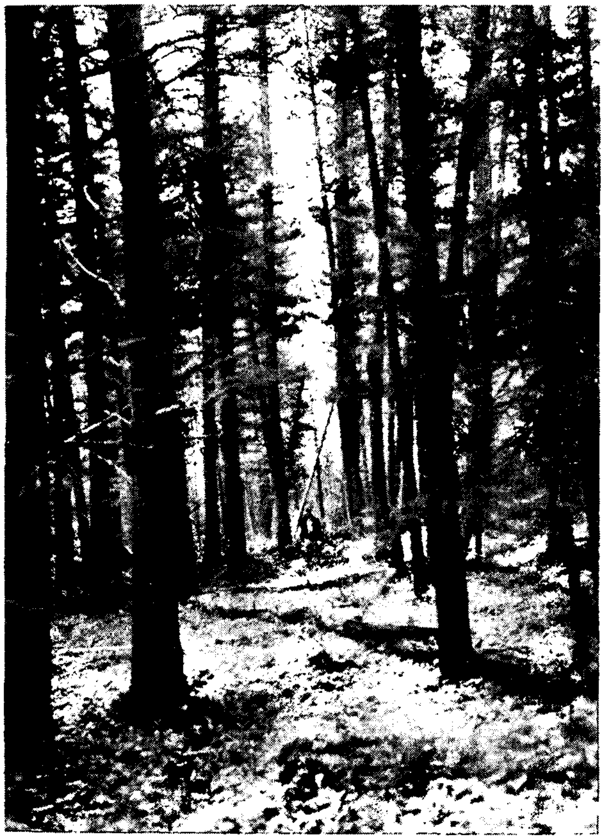

Figure 6. Good Site V Douglas-fir stand in Upper Trout Creek. Note absence of advanced reproduction. Age of stand 240 years.

Figure 7. Poor Site V Douglas-fir Hidden Valley. Age of stand 260 years.

Table 7.

Total Stand and Stock Table of Trees 10-inches d.b.h. and Larger for an Average Acre of Site V Douglas-fir in the Big Belt Mountains of Montana 1/

D.B.H. o.b.	Av. No. 2/ 16-ft. logs	Av. Vol. per tree (Scribner D.C)	Logs per M.	Trees per M.	Trees per acre	Basal area	Vol.per diam.Cl.	Vol.per sq. ft. B.A.	Vol. per acre (Scribner)
Inches	Number	Bd. Ft.	Number	Number	Number	Sq. Ft.	Percent	Bd. Ft.	Bd. Ft.
10	.87	3	33.3	33.3	7.95	4.37	2.8	5	24
12	1.00	4	25.0	25.0	8.33	6.58	3.8	5	33
14	2.07	10	20.7	10.0	10.77	11.53	12.5	9	108
16	2.84	17	16.7	5.9	7.49	10.48	14.7	12	127
18	3.14	23	13.9	4.2	6.06	10.72	16.1	13	139
20	3.20	27	11.8	3.7	3.64	7.94	11.4	12	98
22	3.20	32	10.0	3.1	2.58	6.82	9.6	12	83
24	3.25	38	8.6	2.6	2.09	6.58	9.3	12	80
26	3.27	44	7.4	2.3	1.70	6.27	8.7	12	75
28	3.45	53	6.5	1.9	.59	2.52	3.6	12	31
30	3.42	60	5.7	1.7	.37	1.82	2.5	12	22
32	3.56	74	4.8	1.4	.24	1.34	2.1	13	18
34	3.22	68	4.7	1.5	.11	.69	.8	10	7
36	3.80	97	3.9	1.0	.05	.35	.6	14	5
38	3.00	75	4.0	1.3	.02	.16	.2	12	2
40	3.50	105	3.0	1.0	.02	.17	.2	12	2
42	3.50	111	3.1	.9	.02	.19	.2	11	2
44	4.00	152	2.7	.7	.04	.42	.7	14	6
46	4.00	166	2.4	.6	.01	.12	.2	17	2
Av. 15.7	2.18	16	13.5	6.19				11	
Tot.					52.08	79.07	100.0		864

1/ Basis- Data 10-14 inches d.b.h. based on 353 tenth-acre plots. Other diameters on 353 tenth-acre plots and 249 fifth acre plots.

2/ Each 16-foot log includes .3 foot trim allowance and is 16.3 feet long.

Table 8.

Cull Trees in an Average Acre of Site V Douglas-fir in the Big Belt Mountains

D. B. H. o. b.	Trees per acre	Volume per acre (Scribner D.C.)	Basal area	Percent of Volume
Inches	Number	Bd. Ft.	Sq. Ft.	
10	.14	.5	.08	
12	.14	.5	.11	
14	.52	5	.61	
16	1.37	23	1.92	
18	1.07	25	1.89	
20	.84	23	1.83	
22	.21	7	.55	
24	.42	16	1.32	
26	.30	13	1.11	
28	.23	12	.98	
30	.09	5	.43	
32	.07	5	.39	
34	.05	3	.31	
36	-	-	-	
38	.02	2	.16	
Totals	5.47	140	11.69	16.2

*Percent of Volume in Table 7.

Based on 353 one-tenth acre plots.

Volume table used: Table 10, (Site V)

Cull Tree: 50% or more of the volume defective as estimated by timber cruiser at time of survey.

Table 9.

Merchantable Stand & Stock Table for an Average Acre of Site V Douglas-fir in the Big Belt Mountains (Table 7 minus Table 8)

D. B. H. o. b.	Trees per acre	Basal Area	Volume per acre (Scribner)
Inches	Number	Sq. Ft.	Bd. Ft.
10	7.81	4.29	23.5
12	8.19	6.47	32.5
14	10.22	10.92	103
16	6.12	8.56	104
18	4.99	8.83	114
20	2.80	6.11	75
22	2.37	6.27	76
24	1.67	5.26	64
26	1.40	5.16	62
28	.63	1.54	19
30	.28	1.39	17
32	.17	.95	13
34	.06	.38	4
36	.05	.35	5
38	-	-	-
40	.02	.17	2
42	.02	.19	2
44	.04	.42	6
46	.01	.12	2
Totals	46.61	67.38	724

Table 10.

BIG BELT MTN. DOUGLAS-FIR BOARD FOOT VOLUME TABLE - SITE CLASS V

(Scribner D.C)

D. B. H. o. b.	Height in Merchantable logs to 8" top 2	3	4	5	6
10	7	11			
12	8	12			
14	10	15			
16	10	19	27		
18	11	22	31	35	
20	13	25	37	48	
22	15	29	43	58	73
24	17	34	50	68	85
26	19	39	57	78	97
28	23	44	65	89	114
30	26	48	74	102	130
32		54	84	114	147
34		61	93	128	166
36		68	104	142	185
38		75	114	157	204
40		82	128	176	223
42		89	133	190	247
44		97	152	209	266
46		106	166	228	289

Corrected from Table 4, using 4.9% reduction in volumes as indicated by sample of 85 trees. Volumes for 5 and 6 log trees included since occasionally trees of such height do occur in site V.

keeps the colloidal material dispersed allowing moisture to percolate freely. These soils are well-drained and often exhibit a strong deposition of calcareous and carbonated material in the sub-soil. This is especially true where the area has been repeatedly burned.

Reproduction

Reproduction on site V areas is in the same unfavorable state as site IV stands. Because there are fewer trees per acre, mortality provides more space for advanced reproduction. Therefore, site V may have a slight edge on reproduction over site IV in this regard. However, a reproduction after logging shows about the same on both sites. Tree diseases and insects appear to damage site V stands more than site IV. Under similar heavy moisture conditions, the worst speck rot areas (Fomes pini) were found on site V with smaller trees infected equally as much as larger trees. Site V appears to be more susceptible to insect attack and damage to reproduction in these areas along with site VI is more severe than some of site IV areas have suffered.

Comparison of the Two Merchantable Sites

Table 11 compares the statistics of the two commercial site classes. It shows that site V has smaller diameters, more logs per thousand board feet, fewer trees per acre, and a higher percentage of defective trees. Since the sites were classified on a height basis, we would expect smaller volumes and lower average number of logs per tree for site V.

As a rule site V trees have poorer form than site IV trees. To achieve a similar cut based on equal percents of basal area, it is necessary to cut to a smaller diameter on site V than on site IV. For example, if a basal area cut of 80% is desired, it would take all trees 18 inches d.b.h. and over plus 76% of the trees 16 inches d.b.h. on a site IV. On site V it would include all 16 inch trees plus 80% of the trees 14 inches d.b.h.

Table 11 is an analysis of either internal defects which have no external signs or defects which are not of sufficient magnitude to class the tree as a cull in the original sampling. Data were collected on landings where trees were bucked into logs and also on the green chain as boards came off the saw. Since the trees were not marked as to site class when skidded, it was impossible to classify these defects by site classes. Table 11 is an average of the two sites and in application can be added to the cull tree percent for each site to determine total defect which might be expected for each site class.

Since the total of Table 3 is 12.0% "invisible" defect, the total average cull for site IV stands is 19.8% (Table 3, plus Table 2).

Table 11.

Comparison of Site Classes IV and V (Net Values)

A. Merchantable Trees

Site Class	Av. D.B.H.	Average height in logs	Av. Vol. per tree (Scribner D.C)	Logs per M	Trees per M	Trees per A.	Basal area	Av. Vol. S.F. of B.A.	Volume per acre (Scribner D.C)
	Inches	Number	Bd. Ft.	Number	Number	Number	Sq. Ft.	Bd. Ft.	Bd. Ft.
IV	17.4	3.11	34	9.17	2.96	60.51	108.97	19	2046
V	15.7	2.18	16	13.5	6.19	46.61	67.38	11	724
% Dif. IV over V	11.1%	42.5%	212%	-32%	-52.3%	30%	61.8%	73%	284%

B. Cull Trees

Site Class	Trees per acre	Volume per acre (Scribner D.C)	Basal area	Percent of Volume
	Number	Bd. Ft.	Sq. Ft.	Percent
IV	4.40	174	8.87	7.8
V	5.47	140	11.69	16.2
% Dif. IV over V	-19.5%	24.2%	-24.1%	-52%

For site V stands the total cull is 28.2% (Table 3 plus Table 8.)

Speck rot can usually be detected when marking trees for cutting if trees are "sounded" by hitting sharply with the stamp end of the marking ax on the exposed wood. With experience a timber marker can soon detect the drum-like sound of rotten trees or the flat sound of incipient stages of rot. Doubtful cases can be tested with an increment borer if the rot is near the base of the tree where it can be reached. The 5.1% deduction for speck rot allowed here is for rot which escaped detection either because the tree produced a good ringing sound when hit with the marking ax or the increment borer failed to pierce the rot area.

It is interesting to note that site V on the whole is more defective than site IV. It is possible that the results in Table 3 would substantiate this if data could have been tallied by site classes.

Advanced reproduction on both commercial site classes exists to a limited extent but usually is poor in vigor and health. Many of the trees are so badly suppressed or have such poor crowns as to make recovery if released improbable. Suppressed trees are often diseased or misshapened. Good reproduction does exist in local spots where there are crown openings.

APPLICATION OF THE TABLES

Stand and stock tables may be used in an inexpensive timber survey method. The following method applicable to large areas has been used to make quick estimates of timber volume in a logging chance:

A given drainage is first type mapped by age classes. This is done by using aerial photographs or 2 inch to the mile range survey maps. Usually accurate enough type lines can be sketched in while walking up the creek bottom.

Area of all old-growth, even-aged Douglas-fir is then calculated in acres using either a planimeter or a Bryan Modified Acreage Grid.

The area of old-growth Douglas-fir in the drainage can be divided into site classes by using the Belt Mountain average of 77% site VI; 16% site V; and 7% site IV. Total area is multiplied by these percentages to determine the number of acres of each site. The acres of site IV and V are multiplied by the volume per acre given in the stand and stock tables for each site. This will give the net volume of merchantable Douglas-fir in the drainage 10 inches d.b.h. and over.

In practice, over large areas this method checks within 10% of actual 5 and 10 percent cruise estimates. The cost of such a survey is only a small fraction of a standard survey of 5 percent sampling.

For example, a 5% cruise of trees 16 inches d.b.h. and larger of 2200 acres in the Hellgate drainage showed a gross volume of 5,438 M. b. m. on about 500 merchantable acres. In making a "quickie" it is determined that there are 1694 acres of site VI or protection forest. Site V numbers 352 acres and site IV contains 154 acres. From the stand and stock tables one acre of site V contains 6.99 M. b. m. of trees 16 inches d.b.h.and over. Site IV contains 20.05 M. b. m. of the same class of trees. Therefore:

352 x 6.99 =	2,460 M.
154 x 20.05 =	3,088 M.
Total	5,548 M or plus 2% over the actual survey estimate

Using the net values of 16.2 M per acre for site IV (Table 4 values minus Table 3) and 4.97 M per acre for site V (Table 9 values minus Table 3) of the same class trees, the net total becomes 4,245 M for the quick method and 4,568 M for the regular survey. A difference of minus 9.5% due to the differences in cull factors. The regular survey averaged 16% cull as determined by the cruisers while the stand and stock table plus the cull study averages 23 percent cull. Cost of the Hellgate survey was $600. Cost of the quick method - a few minutes office time. However, the quick method did not furnish a type map or a breakdown by forties or other subdivision. This map could be duplicated for about $50, or about 9% of the cost of the original survey.

A check of 4800 acres surveyed in Indian Creek gives a difference of 9% less for the quick method over the regular survey, on the net volumes, and about 1% on the gross. It is believed that the quick method is closer for Indian Creek since cull percents in the original survey were too low. Actual cutting bears this out.

To apply these tables accurately to small areas the area must be typed into age and site classes as outlined above. Next a check is made on the ground. During this ground check, site class boundaries, cultural features, rock outcrops, and slope percents are drawn in on the base map. Sample plots are taken at random by site classes to determine proper allowance for cull and recorded separately by site classes. Usually only a few sample plots are needed.

In the office a corrected cull factor for the Stock table volume can be determined. Areas of site IV and V are found by planimeter. These areas, in acres, are multiplied by the corrected acre volumes for the applicable site class. The total volume for a drainage is

obtained by adding together the two merchantable site class volumes.

In the fall of 1948 this method was used to survey Ohio and Kentucky gulches, tributaries of Benton Gulch. The results were later checked by a 100% cruise.

A 2 inch to the mile grazing map was used to sketch in site and age class type lines. The following results were obtained for trees 16 inches d.b.h. and up:

Table 12

Comparison of "Quick" Survey Method with 100% Cruise

	Ohio Gulch		Kentucky Gulch	
	Stand & Stock Table	100% Cruise	Stand & Stock Table	100% Cruise
Acres of site IV	7	7.2	--	--
Acres of site V	31	31.8	35	33
Gross Vol. area*	347 M.b.m.	351 M.b.m.	232 M.b.m.	229 M.b.m.
Net Vol. area*	264 M.b.m.	250 M.b.m.	176 M.b.m.	168 M.b.m.
Total No. trees	1071	1013	880	891
No. cull trees	138	126	123	125

* Scribner Decimal C rule

With skill in application of this technique one can cover the Belt Mountain old-growth Douglas-fir stands with a cheap but accurate survey. This method could be adjusted to cover younger aged-stands.

Tables can also be used by the logging operator or timber manager as a basis to compare different logging chances. This can be done by comparing figures on average logs per tree, average volume per tree, average diameter, etc.

INJURIOUS INFLUENCES

Many factors influence the health and growth of timber stands. Fire, logging, insects, unfavorable climate, etc., all exert their influence on the stand. Each of these factors will be discussed separately for the Big Belt Mountain stands of old-growth Douglas-fir.

Fire

The Big Belt Mountains during the last ten-year period (1938 to 1947) averaged about 16 fires per year. Of these, 20% or slightly

more than three fires per year occurred in Douglas-fir stands. The average fire consumed 4.15 acres of Douglas-fir timber or a total burn of 13.5 acres per year or less than .01% burn per year.

The majority of fires are caused by lightning strikes. Man-caused fires in Douglas-fir stands average less than .5 fires per year. The mountain range is given fire protection by the U. S. Forest Service.

The choice timber stands occur on the north and east slopes which remain moist throughout most summers. Most storms move in from the west and south. Little moisture falls while the storms cross the Helena valley from the Continental Divide. Air currents are forced to rise upon reaching the Big Belt foot hills. By the time the currents are forced up over the Belt Mountain divide the air is cooled and precipitation falls on the east slope and mountain tops. The result is more moisture falling at higher elevations and east slope rather than on the Missouri River bench. Since lightning has been observed to precede storms, the dry bench strikes are more apt to cause fires which are not put out by subsequent rains than strikes occurring in the Douglas-fir belt. Another reason for the difference in fire occurrence is due to timber type. Ponderosa pine appears to catch fire from lightning strikes more readily than Douglas-fir.

Since the area is afforded effective fire protection, fire is not a serious problem now. In the past fires left unchecked burned large acreages. In the early days miners purposely burned off whole drainages to expose ore leads. Many of these areas are in an unproductive timber condition today.

Increased logging activity has increased the slash on the ground. There is danger that severe fires may be started in slash areas. Therefore, slash areas must be given increased fire protection during the fire season.

Fire as a Defect Causative Agency

Burning creates conditions favorable for insects to increase and thereby spreads all types of insect infestation because of the weakened condition of surviving timber.

Fire scars give access to butt rots and occasionally brown trunk rot. Some areas scarred by past fires are today so defective as to be almost worthless for saw timber. In addition, many areas previously clean burned are covered with brush and tree reproduction is not satisfactory.

Effect of Fire Upon Soil and Vegetation

Extensive areas heavily-burned have been subject to accelerated erosion. Much of the top soil has been washed away. The quality of some growing sites appears to have been lowered because of past fires.

Under certain conditions Douglas-fir has come in after fire in dense thickets similar to lodgepole pine. In 1929 about 1300 acres of Douglas-fir of which 500 acres were commercial quality were burned over in the Candle Mountain fire. The fire was a hard, clean burn. The 500 acres have sprung up to dense reproduction which is fast growing. Many trees have overtopped their companions by several feet. It is believed that this stand will thin itself out naturally, even though at present the mass of reproduction presents a jungle which can be penetrated only with difficulty. Outside this area reproduction is scattered and of poor quality and the soil shows evidence of accelerated erosion.

Burning appears to cause marked changes in soil acidity, structure and chemical composition. Soil field tests on 6 sites in burned and unburned areas which were logged and brush disposal completed 3 to 5 years ago show: For burned areas a decrease in soil acidity in the A horizon. Increases in total nitrogen content, slight decreases in phosphorus content and slight decrease in potash all in the A horizon indicating that leaching is speeded up. Removal of the humus layer with decrease in acidity increased the rate of leaching enough so that the A_2 horizon on better profiles was better defined. Adjacent unburned areas do not show as good definition. Vegetation on burned spots consisted of moss and liverworts. No reproduction was found inside burned areas. Some scattered reproduction was found outside the burned areas. Burned soils were more compacted and showed from 1 to 2 inches of top soil loss, depending on the steepness of slope and other erosion conditions.

Fire as a Slash Disposal and Stand Improvement Tool

Trees scorched by fire during slash disposal or stand improvement work are most likely to succumb to insect attack. Trees can have the cambium layers killed by slash fire heat and show no signs of char. The needles of "cooked" trees turn brown and the trees usually die within a year. Because the humus and duff layers are thin and soils shallow in the Belt Mountains, broadcast burning appears to do more soil damage than increase in reproduction or decrease in fire hazard may justify and therefore is not recommended except under unusual conditions. In general, the less fire is used the better.

Mechanical

In nature three mechanical influences are exerted on Douglas-fir stands. These are snow, frost, and wind with the latter being the most important.

Snow

Snow does little damage to commercial stands in the Belt Mountains.

Occasionally a wet snow at higher elevations causes severe bending and even breakage of Douglas-fir reproduction and saplings. However, these areas are mostly protection forest type. No commercial stand has been found that is seriously affected by snow mechanical injury.

Frost

Frost injures trees by producing frost cracks and shakes similar to wind shake. Frost injuries of this type can usually be distinguished from wind shake by location. Frost injuries are usually confined to the lower trunk and usually start from the sapwood in. Wind shake as a rule starts from the heart of the tree and seldom pierces the sapwood. Frost may also weaken trees, making them susceptible to insect attack.

Wind

Shake* produced by wind has caused excessive damage in some Douglas-fir logging areas. Shake appears to be prevalent in exposed sites facing the general south or west direction from which come the prevailing winds in this area. Dry sites at lower elevations have more shake than moist sites higher up. In Spring Gulch stands, shake on exposed dry sites becomes excessive at elevations below 5500. Above 5500 feet shake decreases noticeably. Loggers have complained about the brittleness of timber in Spring Gulch, Goodman Gulch, Trout Creek Canyon, and Sweats Gulch. The greater portion of these stands were below 5500 feet elevation. Shake again becomes a factor when elevations of 6800 feet or more are reached, possibly due to increased exposure. Losses from shake ordinarily do not exceed 1 percent.

Compression failure is a form of wind damage. It has not been reported as much in this country as in Europe.

Abnormal amounts of compression failure were first reported by

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*Wind shake is caused by high winds which bend tree trunks sufficiently to cause the wood fibers to separate at the neutral plane between compression and tension forces. A tree bent by wind has the windward fibers under tension and the leeward fibers under compression forces. When these forces are great enough, it causes failure of the wood fibers. Failures are of two types; radial splits, and cracks or separations following the contour of the annual ring. In the latter, failure takes place between spring wood and summer wood of the preceding year's growth.

Floyd C. Hysell, logging operator in Spring Gulch. The worst area appeared to be below 5500 feet in elevation, on drier than average sites, and well exposed to the prevailing wind, also in a portion of the creek canyon which acted as a funnel for the winds. In this portion of the creek, it was noted that high winds were blowing when other portions of the stand were quiet.

Compression failure is due to excessive compression being placed on one side of the tree so that the fibers are crushed rather than split as from normal shake. This can be caused by hurricane winds or rough handling while falling. Wind failures usually "pitch up" after a few years and can be detected from failures due to rough felling which are pitch free in the cracks. Felling failures usually cannot be detected until the log is milled and the boards dry for a few days. The cracks then open up from shrinkage due to drying and the boards literally fall apart and are useless for lumber.

Studies indicated that failure in brittle timber from lower areas in Spring Gulch ran as high as 72% and averaged 37½%. Such timber can not be logged at a profit unless logging costs are very low, to offset the higher operating costs in terms of sound lumber.

Other areas have little of this failure except at lower elevations. Spring Gulch, the worst area encountered so far, is different than other areas as it drains towards the prevailing winds, and there are no high ridges for protection between it and the prevailing wind. It is the only stand which has been logged to date which faces directly into the prevailing wind.

Another type of wind injury is "Red Belt" or winter injury due to "Chinook" or warm winds when the soil is frozen. Extensive Red Belts occurred in January, 1943, when a strong, warm wind swept the Belts for several days. Temperatures rose to 55° F. in mountain areas.

Tree Diseases

Fungi are common causal organisms concerned in tree diseases. Douglas-fir in the Belt Mountains is susceptible to attack by a number of these organisms. Some areas such as Indian Creek, a tributary of Trout Creek, are seriously infected with speck rot (*Fomes pini*) or with butt rot (*Polyporus schweinitzii*). Infections are so serious in some instances as to make logging unprofitable since not enough sound logs can be harvested to keep overhead costs within a reasonable margin.

Following is a list of diseases identified in Douglas-fir stands of the Big Belt Mountains:

Butt rot (caused by *Polyporus schweinitzii Fr.*) forms a brown cubicle rot of roots and butt logs. The fruiting body is usually found in the duff adjacent to the infected tree. Highest degree of infestation is found in stands which have been subjected to a ground fire. Rot gains entrance through fire scars. Areas in Indian Creek, Trout Creek and Hellgate Gulch which have experienced ground fires in the history of the present stand are heavily in-

fested. In Indian Creek, Block III, Lower-Bowman Gulch had 20% of the trees infected. Rot ran up an average of $7\frac{1}{2}$ feet from the ground, requiring an average of 6 feet to be butted off from the butt log. Loss in gross scale on the whole area was 3% from this rot. Fire protection and care in logging, slash disposal and stand improvement work will hold down the spread of this disease in the future.

Brown rot (caused by Polyporus sulphureus (Bull) Fr.) produces a rot not easily distinguished from other brown rots except by the fruiting body. Occasional fruiting bodies have been found in this area where ground fires have occurred. It has not produced any serious infestations that are known.

Red ring rot - locally called "speck rot" (caused by Fomes pini (Thore) Lloyd). This is the most serious disease in the Big Belt area. In Indian Creek some portions of the stand run as high as 70% infected. Most of the rot is in the late stage and the entire tree is a loss. Heaviest infestation appears to be on medium to heavy moisture areas where stands are over-aged. Removal of overmature, suppressed, injured and infected trees would go a long ways in controlling this disease. In some areas, such as Block IV in Indian Creek, this would amount to clear cutting since trees 3 and 4 inches d.b.h. are infected. Overmature stands which have better than average stems per acre with a suppressed understory seem to be a focal point for this infection.

Shoestring rot (caused by Armillaria mellea (Vahl.) Quel.) has been found scattered throughout the district but is not a serious menace. Fire-scorched trees and insect infested trees appear to be the trees attacked. Although one or two cases have been found where the rot has apparently spread through the ground to adjacent uninjured trees.

Brown trunk rot (caused by Fomes laricis (Jacq.) Murr.) has been found in Spring Gulch area in Whites Gulch and in Benton Gulch stands. Losses have been as high as 3% of gross volume. On the whole this fungus is not serious.

Red belt fungus (Fomes pinicola, Swartz) is the common scavenger fungus of Douglas-fir stands in this area. Many conks have been found on down timber and dead trees.

Rose colored brown pocket rot (caused by Fomes roseus Fr.) has been found occasionally on injured trees but does not appear to be extensive.

Brown sap rot (caused by Lenzites sepiaria Fr.) is an extensive slash rotting fungus in the area.

Scaly cap rot (caused by Lentinus ledpideus Fr.) has been found fairly frequently on slash and down logs of lodgepole pine found intermingled with Douglas-fir. Conks have only been found on down timber.

Needle blight of Douglas-fir (caused by Rhabdocline pseudotsugae Syd.) has been observed. It is not very prevalent at the present time, but it does exist in the endemic stage on reproduction.

Dwarf Douglas-fir mistletoe (caused by Arceuthobium douglasii (Eng.) may be present in the area but does not present a serious problem. Only a few witches brooms have been observed throughout the Belt range. Cut over areas appear to be free from this disease.

Insects

Insects are a serious disturbing influence in Douglas-fir stands. Infestations of epidemic proportions have occurred in the Big Belt Mountains following fire, logging, severe winters, and construction and mining activities. Infestations which have not killed green trees such as initial attacks of spruce budworm (Cacoecia fumiferana, Clem.) may be followed by another infestation of bark beetles (Dendroctonus pseudotsugae, Hopk.), which results in a high percentage of tree fatality. Construction and mining activities have caused infestations when damage to green timber has been severe.

The following insects have been observed at work in this area:

Adelges cooleyi (Gill) - cooley's adelges or plant lice have been observed in endemic in infestations. Since this species requires spruce as an alternate host it probably will never be a serious factor in timber management in this area since spruce occurs in limited stands. It produces small galls 12-75 mm long and 12-18 mm wide on spruce. It destroys the terminal buds of spruce often deforming the growing trees. Galls on young trees kill the terminal shoots and leaders. On Douglas-fir it causes the infected needles to turn yellow and be cast off.

Buprestis aurulenta, L. - golden buprestid is found on scars and working in pitch. It causes damage in lightning scarred, fire scarred, or otherwise injured trees. In logged-off stands, many stumps show infestation signs made by this insect. Where logging damage to the residual stand is severe, insects move from stumps to weakened trees. Infected trees may be killed by an additional attack of bark beetles. For this reason alone, low stumps and decreased logging injury are working goals in Douglas-fir management.

Cacoecia fumiferana(Clem). - spruce bud worm is in a severe epidemic stage now. The epidemic first moved in from the southern end of the range. First mass flights of moths were observed in 1943, although the insect had been found working on the east slope prior to this time. The winter of 1942-1943 was marked by a mild spell in January. Immediately following this chinook period, the temperature fell from about 50 degrees above zero to more than 40 below zero. The warm winds caused extensive "Red Belt." The fol-

lowing summer, heavy bud worm activity was observed in these areas.

During July, 1943 the first of the big moth flights occurred. These increased in intensity each season until the peak was reached in 1945. Since then, flights have been decreasing each year. Some of the attacked stands have experienced subsequent beetle epidemics which have killed large Douglas-fir acreages. Other areas have been thinned by secondary infestations or have been wiped out by repeated attacks of the budworm.

Severest infested stands were those which suffered winter kill or "Red Belt" damage. These areas appear to be in a belt coinciding to the thermal layer, that is, occurring about midway up the main slopes of the range. Heavy kills occurred almost entirely on site V and site VI (protection forest). Exposed slopes and dry sites were hit hard with old stands or badly suppressed stands suffering the most.

In the better sawtimber stands, the overmature trees were killed outright by the initial attacks as were rot infested trees (Fomes pini) and badly suppressed and injured trees. Young, healthy, fast-growing trees recovered from budworm attacks in a few years and now appear to be none the worse for wear. In these stands the thinning out of the old or defective trees probably did more good than harm.

Dendroctonus pseudotsugae, Hopk. - Douglas-fir bark beetle is widely spread in the endemic stages. In Trout Creek drainage from the upper Canyon to the Missouri River, an infestation has been increasing in severity for about 10 years. The drier slopes have suffered the most, although the overmature trees in the canyon bottom are now heavily infested. William Dobler, a local sawmill operator under Forest Service permit is logging out the infested trees in the canyon in an effort to control the infestation in the scenic portion of the canyon which has great recreational and aesthetic value.

The canyon infestation is believed to have originated in a logging area at the lower end of the canyon. In 1940, bark beetles were confined to the endemic stage. That same year, 100 M.b.m. were logged off the lower end of the canyon. Slash disposal was done by inexperienced men resulting in many badly scorched trees in the residual stand. The next few years Ips spp. (Douglas-fir engraver) and bark beetles increased and attacked stumps, injured trees and down material left in the woods. About 25% of the residual stand over 10 inches d.b.h. succumbed. Some control was instituted in 1941-44 by removing injured and infected trees for fuel wood and bridge timbers. A thorough job was not done, and the bark beetles moved from the logged off area up canyon to adjacent virgin timber, resulting in the present infestation. A road was constructed up the canyon in 1941, leaving considerable down trees and logs in the right-of-way, aiding the spread of the infestation up canyon.

Figure 8 shows an area left after logging which subsequently suffered severe attack.

Hylastes nigrinus (Mann) - Douglas-fir root bark beetles excavate winding mines in the bark of roots of trees dying or recently killed. Usually they are confined to the roots and trunk. This insect comes in after logging much the same as Ips and Golden buprestid and probably shares equal responsibility for infection of severely injured trees.

Dioryctria zimmermani (Grote) - Zimmerman pine moth causes spike tops in lodgepole stands but has been found in Douglas-fir. It prefers the vigorous healthy trees, although it requires a spike topped tree for a brood tree.

Ips spp. - engraver beetles have been found in the area. In logged-off areas, they probably are next to Dendroctonus in importance. The external evidence of their work is boring dust which is usually dry and free from pitch. The dust may be seen in bark crevices. The beetles usually spend the winter in the adult stage under the bark of trees killed the previous year or drop to the ground and hibernate under bark scales at the base of the tree. Larvae are found in chambers usually in congregations. Chambers are bored in the cambium layer where the larvae feed. Death to the tree results from girdling caused by the chambers. Figure 9 shows a logged off area which will suffer less insect loss than the stand in Figure 8 because of lack of brood material.

Pityophthorus pseudotsugae SW., - Douglas-fir twig beetle attacks the twigs and tips. This species has been observed doing extensive damage in Whites Gulch and Avalanche Creek.

Scolytus unispinosus Lec. - Douglas-fir engraver attacks injured or weakened trees. Species found but not a serious menace

Synanthedon novaroensis HyEdw. - Douglas fir pitch moth causes pitch flows from burrows. This is a heavy attacker in the Belts in certain areas but does not seem to kill. The damage is in the reduced lumber quality because of pitch pockets and seams caused by the larvae.

Other species of insects which have been reported in this area but have not been identified in connection with this study are:

Asemum atrum Esch. - black spruce borer

Chionaspis pinifolia (Fitch) - pine needle scale.

Chrysobothris sylvania Fall - Douglas-fir flatheaded borer.

Chrysophana placida Lec. - Douglas-fir borer.

Figure 8. Slash Area - Poor condition.
Slash left on ground, long butts, high stumps, unmerchantable tops, injured trees, all are breeding material for Ips and Dendroctonus. This stand cut in 1947 and subsequently suffered insect damage. Age of stand 220 years.

Figure 9. Slash Area - Good comdition.
Picture taken 90 days after winter logging, 100% cleanup job was done. Residual stand suffered very little insect loss.

Dicera sexualis Crotch. - wood borers.

Anthaxia pseudotsugae Cham. - Inner bark and outer wood borers.

Gnathotrichus sulcatus (lec.) - wood stainer.

Dryocoetes pseudotsugae Sw. - Root bark beetle.

Halisidota argentata Peck. - silver spotted halisidota.

Man

Logging, grazing, mining and other activities of man aggravated by his carelessness and abusiveness add up to the greatest single influence forest lands are subjected to. Man's influence is greater than the combined forces of climate and biotic influences other than man. This influence of man must be creatively directed if we are to continue to have timber resources. Two of the most important influences of man in the Belt area are grazing and logging.

Grazing

Cattle and sheep grazing is part of the multiple land use of timbered areas in the Belts. Conservative grazing has little effect on reproduction on side hills and ridgetops, but stock concentration areas in creek bottoms tend to keep reproduction down. Heavy sheep use, especially around bed grounds, has kept reproduction from becoming established. Except in overgrazed areas, damage is not severe.

Cattle "shading up" under certain trees build manure piles which appear to burn the tree the same as too much fertilizer on a garden crop. Certain groves of trees have been selected by cattle as favorite grub rubbing spots. Trees have had their bark rubbed so thin that damage to the tree has resulted through insect attack or fungus infection.

Logging

Logging results in detail will be discussed in a separate chapter. However, logging is the greatest disturbing influence on Douglas-fir in the Belts other than insect attacks which may be closely related to logging.

In this area destructive cutting accelerates erosion, increases surface runoff and spreads insect and fungi infection through the residual stand. All logging does this to some extent. Stream flows increase after logging in certain areas, at least until the logging scars heal. Snow goes off faster in the spring. If the cut has

been too heavy local floods may result. Some streams which have been intermittent for years have suddenly flowed year round with good heads immediately after logging, while streams in adjacent undisturbed gulches remain dry or intermittent.

Wild Life

Wild game affect Douglas-fir very little. Deer prefer juniper or other browse during severe winters and do not cause much damage to Douglas-fir reproduction. Elk prefer alpine fir, Engelmann spruce, or lodgepole pine when rubbing the velvet off their horns. Douglas-fir bark is too thick and coarse and seldom is a tree of this species selected for the job.

Porcupines and snowshoe rabbits attack younger trees but on the whole, damage done to Douglas-fir is negligible even though adjacent lodgepole stands or trees are badly damaged.

THE EFFECTS OF PAST CUTTING PRACTICES

During the course of this study, field observations were made on all cutting areas known in the northern half of the Belts. Some of the principal cutting areas in the southern portion were also visited.

Types of cutting found can be classified into three general types: selective logging, clear cutting, and partial cutting (cutting to a diameter limit).

Definition of Terms

The term selective logging as used in this report describes cuttings where only the best lumber producing trees were removed from the stand. Defective, crooked, and not readily accessible trees were left standing. These included trees the operator didn't care to handle because of more than average taper, short height, forked boles, trees which were difficult to fall, excessive limbiness and trees which fallers just did not like the looks of.

Clear cutting is used to describe areas where all the trees of any size were removed. Cordwood cuttings for smelters for instance, could make use of any material down to a few inches d.b.h. even if defective.

The third term, partial cutting, as used in this report, describes a selection type cutting usually to a diameter limit of 12 to 16 inches d.b.h. An effort was made to remove defective trees at least down to the diameter limit. Some cuttings succeeded in removal of smaller defective material. Others clear cut to a specific

diameter limit with varying success as to defective tree removal. In still other cases, selection was based on removing the slow increment producing trees down to a specified diameter limit with some defective tree removal below that limit. Partial cutting is distinguished from selective logging in that while both are partial cuts, selective logging removes only the best trees from a lumber producing standpoint and leaves the defective, misshapen trees in the residual stand. Partial cutting attempts to remove the defective trees along with the best trees although good trees may be left in the residual stand. It means cutting only trees producing less annual increment per square foot of basal area than might reasonably be expected of a young mature tree. A diameter limit is usually established to prevent cutting too deeply into the capital growing stock.

Selective Logging

Trout Creek

The principal area of selective logging studied was in upper Trout Creek in Sections 23, 24, Township 12 North, Range 1 East and Section 19, Township 12 North, Range 2 East, Montana Principle Meridian. These sections are all in private ownership within the Forest boundary.

A local sawmill operator cut the trees he desired and paid the landowner $2 - 3.00 per M. b. m. on the stump. Land owners exercised no control over cutting. No stand improvement work was done but brush disposal was done to the minimum state law requirement of 25¢ per thousand board feet of logs cut. Brush disposal work was done by the Forest Service under cooperative agreement between the operator and the State Forester. Tractor skid was used.

Plan of slash disposal was to dispose of brush 50 to 100 feet back from main skid trails and haul roads. Cutting started in the summer of 1941 and continued during the field season months and is still going on. During this period a total of over 3,000 M. b. m. has been cut and slash work completed.

Timber stand at start of logging was about 250 years of age and was dense in volume, probably averaging 20 M feet per acre with some acres as high as 50 M feet. There was much evidence of past ground fires probably 50 to 100 years ago. Lower fringes of stand, adjoining mountain meadow along creek bottom, had an intermingling of lodgepole pine and alpine fir. Here and there were small patches of younger age class trees. Soils are chestnut brown to grey brown podzolic on the better sites and raw lithosols on the poorest sites. There is some soil deposition over litter in certain areas indicating that accelerated erosion followed ground fires of the past. Stand had the usual amount of speck rot and butt rots found in this type. Insect activity was in the endemic stage.

Present condition of the stand is not too good. Smallest tree removed was about 16 inches d.b.h. Only the best trees were removed. Too many overmature, defective trees are left standing. Trees with broken tops, or forks, or bad crooks are left uncut. Many trees were undercut and never felled. Insect activity increased. About 75 percent of all stumps show adult emergence holes. Trees injured in logging have been attacked by beetles and many have died. Wind throw has been light with less than one tree per acre below 16 inches d.b.h. having been windthrown. Along the skid trails scattered here and there through the pine grass are a few 3 to 5-year lodgepole pine seedlings. While there is easily enough volume to support another cutting on a salvage basis, there is little chance that anyone will be interested in such an operation until too late.

Conclusions are that the cut was not heavy enough. It was too selective; more of the defective trees should have been removed to improve the growing condition of the residual stand. Trees injured in logging are now dead from insect attack. It would have been better silviculturally and economically to have removed these at the time of logging. Erosion, while not serious, could be stopped altogether by placing a few buffer logs across skid trails where water runs down. Skid trail cutting by runoff was the only accelerated erosion evident. Trees scorched by slash fires were later killed by insect attack. Reproduction presents a problem as few seedlings of fir have started since logging. The stand has been overgrazed by both cattle and sheep since logging. Many of the new seedlings have been damaged. Overgrazing may have prevented survival of additional seedlings. Since only about one-third of the basal area was removed, the cut may be too light to get satisfactory reproduction started. It is believed that if a salvage operation is not instituted by the land-owner, a badly defective timber stand will result by the next cutting cycle.

Spring Gulch Area

Spring Gulch area in Sections 10, 15 and 16, T. 10 N., R. 2 E. was probably logged in the 1870 to 1890 period. The land is now National Forest land and has been since the Forest was set aside. Soil is the same as in Trout Creek, with much the same past history. Charred wood was found as deep as 2.4 feet where soil deposits have been made from erosion or creek bed washes. Age of the timber is 220-240 years. Trees show release 62 to 67 years ago. Logging probably took place over a period of years since only the needs of a local mining camp (Whites City) were supplied. White's city was a town of about 100 people, of which no trace remains today except the sluiced earth.

The volume removed was greater than the Trout Creek area, but the volume of timber remaining is large because of the heavy original stand. Reproduction, except where slash had been broadcast burned and where cut was heaviest, is mostly lacking. This may be due in

part to grazing since the bottom along which logging took place is a favorite shading-up area for cattle. The area has been grazed about 60 years; by sheep in early days and by cattle in the last 30 years.

Stand is in good growing condition and is now being logged again. However, parts of the area are exposed and trees that were left which had insufficient protection are badly windshook and subject to compression failure. Tree 706 on the Floyd C. Hysell sale of 12-20-46 shows several decades of three-inch diameter growth in the early life of the stand. The tree was 36 inches d.b.h. and 6 logs high. It scaled better than 2000 board feet and was 215 years old. Stand has some butt rot and insect activity. Spruce bud worm has killed many trees under 50 years of age. Many dominant trees have produced less than 3 inches of increment during the last 30 years.

Conclusions arrived at from study of the Spring Gulch stand are that the original cut was about right for the age of the stand except on the exposed sites. Here the better plan would have been to remove all trees too tall to be protected by the residual stand. Defective trees should have been removed. The second cut is about 30 to 40 years later than desirable.

Conclusions on Selective Logging

Selective logging is not the most desirable practice because the cut tends to be too light and leaves defective trees to put on increment whereas either a good tree could be established or growth accumulated on a good residual tree. A number of other early day operations in Bilk Gulch and Number 16 Gulch substantiate this conclusion. Reproduction is a problem under this method, especially when the areas are overgrazed by livestock.

Clear Cutting

Only one area of clear cutting has been found. This is in Hellgate Gulch along the main bottom and up Carpenter Gulch, a tributary of Hellgate.

From evidence on the ground it appears that the stand was a typical Douglas-fir type about 220 years old at the time of cutting. Logging commenced about 1907 and ceased about 1918. Material cut was used in the Argo copper mine which is situated below the logging area. Cordwood was also hauled for use in the smelter at East Helena. Part of the area was broadcast burned through carelessness on the part of a woodsworker in the summer of 1919. Reproduction in the old burn is excellent. Also, it is satisfactory in the areas clear cut but not burned.

However, much of the top soil on the burned areas has slid down into the creek. While the scars are healed over, a lot of good

top soil has been removed and carried down stream or deposited along the canyon bottoms. Unburned areas show effects of accelerated erosion in the past which has now been arrested by the establishment of sufficient ground cover. Spruce budworm has not infected the reproduction as yet. Other insect activity seems to be endemic. No needle cast or other fungus disease were observed.

Conclusions on the clear cutting method are that it does give satisfactory reproduction in this case at least. However, such a method requires 200 years to produce a stand of timber. It is a dangerous treatment to the soil since so much of the soil mantle on slopes over 10 percent is apt to slip down hill. This may cause a decrease in site quality.

Removal of too much of the protective vegetative cover may result in local floods or at least increased stream flow for a few years. It is felt that some other method is more desirable from a soil management and watershed management viewpoint. Clear cutting by strips such as in lodgepole stands is not possible because merchantable stands are along stream bottoms and would not be suited to such a method.

Partial Cutting

On most government sales a plan of partial cutting was followed. In the lower scale of silviculture this may have meant clear cutting down to a certain diameter limit such as 14 inches d.b.h. In other cases, it may have been a better job of marking in which thrifty trees were left in the residual stand above the limit with an effort being made to mark all the defective trees above 14 inches. The thought was held that in forty years another cut nearly as heavy as the first could be expected. After the first two cuttings the stand would be developed with haul roads and skid trails to make feasible a high grade of selection cutting. The stand would resemble an uneven-aged stand and would be less subject to the ills of even-aged stands. Figures 10 and 11 illustrate improper skid trail location and erosion effect.

Partial cutting was not put into any large amount of practice until the 1930's. About 7,500 M feet has been cut under this plan of management in the last 12 years.

Conclusions based on a survey of these operations lead one to the following: The idea is excellent in theory but so far the result in practice leaves much to be desired. The biggest stumbling block is the lack of subsequent reproduction and the heavy insect kill after logging. Only one stand, Goodman Gulch has anywhere near a satisfactory stand of reproduction started. Most stands have too many injured and defective trees left standing. Many of the trees left for the second cutting cycle have succumbed to insect attack brought on by poor slash disposal, injuries received during logging

and the amount of large material such as long butts, rotten trees and unmerchantable tops left in the woods. Some trees appear unable to withstand the opening up of the stand and die.

In some cases the cut appears too light. In some instances there has been an opportunity to send in another operator 5 to 10 years later. This helps somewhat but because of the poorer quality of the cut, it is difficult to get rid of many defective trees that should be removed.

Some defective stands should be cut as clear as possible without starting too much stream-flow increase, or soil movement. Other cut-over stands have trees left which will never survive until the next cut. These should have been removed, leaving some of the more thrifty larger trees which were cut. In Indian Creek all the trees even down to a few inches d.b.h. are 260 years old. Normally the trees 10 to 16 inches d.b.h. make up the residual stand. It is doubtful if many of these will survive or respond to release since their crown vigor appears poor. Under the present plan, 2/3 of the trees 10" and up are to be cut, saving the better trees below 18". If the trees of low risk between 16 and 20 inches were reserved, about 30% of the trees would remain. This would leave the best growing trees for the next cutting cycle as well as the most likely to survive. However, speck rot and insect attack are so hazardous in this old stand that clear cutting in some blocks would be desirable if it could be obtained.

Reproduction, as mentioned, is the great stumbling block. Planting may have to be resorted to. Since stand improvement funds are now being collected on Forest Service timber sales, the amount collected could be increased to allow for planting on site IV stands.

REPRODUCTION 10/

Establishment of reproduction on cut-over land is one of the most important problems confronting the forest manager. Therefore, it has been made the subject of a separate chapter.

Climatic Factors Affecting Regeneration

The growing season is approximately three months during June, July and August. Killing frosts may occur during the first week of June and the first week of September. During the growing season, low temperatures on the north and east slopes and high temperatures on the south and west slopes combined with low precipitation and low humidities accompanied by high evaporation rates often produce critical conditions for the establishment of natural regeneration.

10/ Material in this chapter is largely taken from "Proposed Management Instructions for Eastern Montana Douglas-fir" U.S.F.S., prepared by the author.

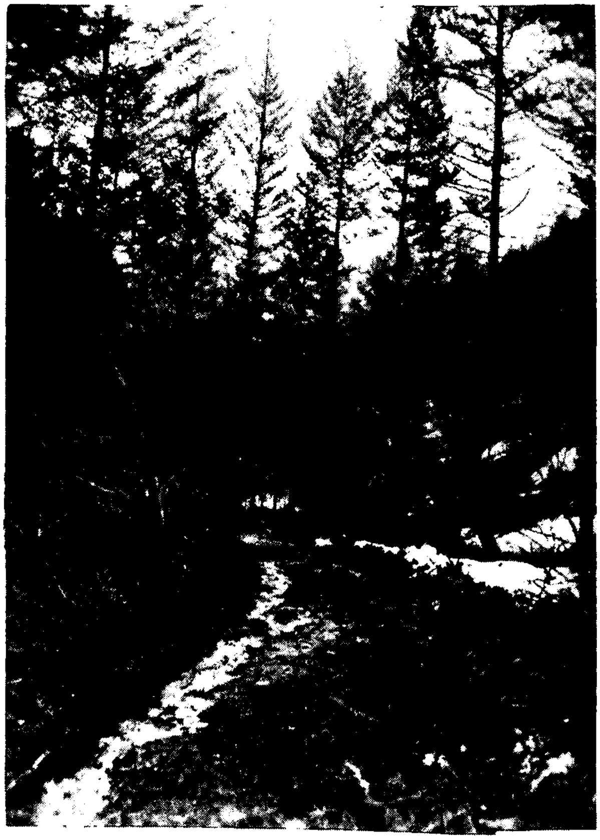

Figure 10. Improperly located side road, Hellgate.

Notice water running off on road. If trail had been located 50 feet higher above creek bottom it would have missed series of springs which were opened up on low location.

Figure 11. Erosion deposit from washing of skid road in Figure 10.

Six inches of silt deposited at mouth of gulch after spring flood.

Seed Supply

Douglas-fir trees are prolific seeders during good seed years which occur every 5 to 10 years. Numbers of seed produced per tree varies greatly but sizeable crops of 10 to 40 thousand seeds per tree are produced during good years. 11/

Douglas-fir trees begin seed production at ages of 20-40 years. Old growth stands may not produce viable seed crops most years.

Seed dissemination of Belt Mountain Douglas-fir usually begins in the first part of September. Since cones open in dry weather after maturing and partially close in moist weather, period of seed dissemination may vary according to occurrence of wet or dry weather. Usually the bulk of the seed falls by the end of October following a fall dry period.

Seed remain viable but one year. Seed stored in the duff show almost no viability the second year. Rodents such as the white footed mouse and pine squirrel consume large quantities of seeds and seedlings. They may be a factor in the inability to secure natural regeneration in this type. Mice populations are known to increase greatly after logging. Espectially is this true where slashing, long butts and tops are left after logging and slash disposal. Large populations do not, as a rule, occur in uncut stands. 12/

Seed stored in the duff may be of insufficient quantity for natural regeneration. The same may be true of seed produced at the time of logging. It cannot be relied upon for natural regeneration. Since logged areas are usually confined to creek bottoms and lower slopes, such areas can be clear cut. Residual trees higher up the slopes will serve as seed sources.

Germination

Germination begins in May or June at lower elevations, and on exposed sites. Killing frosts may occur at this time and survival of seedlings may be reduced. At higher elevations and protected sites, germination may not start for as much as four to six weeks later, occurring during the frost free period. Reproduction is usually more satisfactory at higher elevations and on protected sites.

11/ Isaac, Leo A., Reproductive Habits of Douglas-Fir, Charles Lathrop Pack Forestry Foundation 1943, Washington, D.C. 107 pp. Illus.
12/ Krauch, Herman, Management of Douglas-Fir Timberland in the Southwest, 1948, 88 pp. Illus. Unpublished paper.

Burned areas with blackened mineral soil on exposed sites may be detrimental to germination and seedling establishment because of high soil surface temperatures. Isaac 13/ reports Douglas-fir seedlings being killed in nursery beds when soil temperatures reached 125 degrees F. Soil color may be a factor affecting soil temperature. Grey-black soil surface temperatures are higher than yellow-brown surface temperatures under the same conditions.

Germination takes place readily on duff provided the overhead canopy is thin enough to provide only partial shading. In deep, narrow canyons overhead shading must be less than on more open sites because of the shading effect of the topography.

Seedling Establishment

The establishment of seedlings is the tough hurdle in management. Many seedlings die the first year. Losses may continue heavy for a few years. Seedlings 4 or 5 years old are fairly well established.

Seedling establishment is best under open conditions or under light partial shade. Burned areas not too heavily stocked with brush offer highly suitable conditions. Clear-cut areas are likewise highly favorable to seedling establishment, provided moisture deficiency and exposure are not too severe.

Seedlings appear to grow best on a slightly acid soil. Hard-burned areas usually result in a neutral or alkaline soil. It is possible that it may be necessary to permit shrubs to occupy the area first in order that burned soils may develop an acid condition again and thus become favorable to seedling establishment.

Seedling establishment is poor where overwood is too dense. At higher elevations alpine fir reproduction may be favored over Douglas-fir when the canopy of the original stand is too heavy. Dense growths of shrubs or aspen may inhibit good seedling establishment the first few decades after fire or logging. However, shrub growth areas usually thin out in 20 to 30 years and become more favorable to Douglas-fir establishment.

In most stands 10 years after logging, sufficient seedlings of Douglas-fir were not found. The last 10 years may not have been good seed years in certain stands. Some road cuts and skid trails made over 10 years ago do show dense stands of Douglas-fir seedlings being established. Part of the natural regeneration problem may be waiting for a good seed crop year.

It is very likely that in dense overmature stands the dominant as well as the suppressed trees may have lost viable seed producing ability. as a rule overmature trees that are heavy cone producers

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13/ See Footnote 11/ on Page 51.

have not been observed. It is questionable whether a suppressed tree over 200 years old will regain any seed producing capacity if release if possible.

It appears that hope of seed production lies in advanced reproduction which may exist in crown openings and which are only slightly suppressed by the main story. Removal of the overstory may have some effect on seed crop stimulation in these younger trees.

Early Development

After establishment Douglas-fir grows best in areas where the overwood is light and competition from other growth is small. Development is most rapid at medium elevations on protected sites under clear cut conditions. Growth on south and west aspects may be slow, especially is this the case where there is an absence of shade where there is too much overwood.

Growth After Cutting

Accelerated growth may be achieved in advanced reproduction after partial cutting. On the other hand, if the cutting is too light to sufficiently open up the canopy, subsequent reproduction is extremely slow in establishment and its growth and development is poor.

SUMMARY

The Douglas-fir forest of the Belt Mountains, east of the Continental Divide in Montana is a valuable natural resource, which in recent years has assumed increasing economic importance because of diminishing national timber supplies. Studies were made to learn more about its requirements for sustained timber production, including relationships to management and protection of the associated resources, soil and water. Information reported here is based upon material collected by the author, partly in connection with official duties as an officer of the United States Forest Service and partly through personal investigations, as well as upon a review of published literature.

Terrain in the area studied is rugged and mountainous. Major geologic formations are uplifts composed of slates, quartzites and limestones with igneous intrusions. Several valuable minerals, including gold, are present in the rock. These minerals have led to extensive mining which has resulted in logging and man-caused forest fires during the past 80 years. The steep slopes and rock outcroppings make logging expensive.

The climate is typically continental in character--relatively low precipitation, wide extremes in temperature, and a frost-free

growing season of only 90 days or less. There are many local variations in climate due to the rugged topography.

Soils are generally shallow except in areas of soil deposition in stream bottoms. They vary greatly in texture, color, structure, and depth, depending upon parent materials, slope, aspect, and other factors. Although the soils are generally immature and have incomplete horizon patterns, some podzolization is evident and layers of leaching and deposition can be found. Site quality for growth of Douglas-fir was observed to be somewhat associated with certain soil characteristics. The better stands were generally found on deeper, acidic soils with a greater accumulation of organic material.

Douglas-fir forests generally occur at elevations of 4,000 or more feet above sea level. Above 7,000 feet, the timber is usually too poor to have commercial value. Non-commercial stands make up 77% (Site VI) of the Douglas-fir forest type. Stands of commercial quality are composed chiefly of site V (16%) and site IV (7%). Associated tree species include ponderosa pine, lodgepole pine, alpine fir, Engelmann spruce, juniper, and limber pine. In general, these trees do not offer serious competition to Douglas-fir within its zones of best development.

The shrubs, forbs, and grasses which grow in association with Douglas-fir or in openings in the stands, have considerable value as forage. Grazing of sheep and cattle upon this vegetation is an important local industry which has been practiced for the past 70 years. The forage also is used by elk, deer, and several kinds of smaller herbiverous wild animals.

Stand tables and volume tables were constructed for sites IV and V. These tables can be used to estimate, cheaply and quickly, timber board foot volumes for mature stands where the acreages and site qualities are known. The volume tables also are useful for accurately estimating timber volumes by accepted timber cruising methods. Correction factors for cull, both external and internal, have been computed.

Stands tend to be even-aged. They mature at around 220 years. Destructive forces such as fire cause many stands to be 2- or 3-storied, but truly all-aged forests are rare.

The principal agents which are injurious to forests and forest soils were investigated. These include fire, climatic factors, insects, disease, and man. Fire apparently has always played an important role in the life history of Douglas-fir forests. Fire-killed stands generally regenerate well. Considerable erosion has resulted from fires. Insects and diseases cause extensive destruction of trees and wood. Loggers prefer to leave cull trees which results in degraded stand quality and reduced net growth. Logging

can influence bark beetle populations, eitherlpositively or negatively, depending upon the silvicultural methods (tree selection and slash disposal) employed.

Old cuttings were investigated to learn the results of the logging and cutting practices which had been used. Growth on residual trees was usually, but not always, disappointingly small. The low net growth apparently resulted chiefly from cutting too many of the vigorous trees, leaving too many poor vigor and cull trees, logging and slash disposal injury, bark beetle attacks, and wind throw. In general, it appears that undersized and cull trees should be destroyed to make room for new growth. As a rule, cutting should be heavy or clear. In places, however, improvement cutting would result in accelerated growth.

Logging debris should be eliminated in order to prevent outbreaks of bark beetles. However, broadcast burning of slash is undesirable because it encourages erosion and destroys organic material.

Road location, design, and construction are important from the standpoint of soil and watershed management. No logging engineering practices should be permitted which are substantially harmful to soil and watershed protection.

Prompt regeneration of Douglas-fir following logging is a difficult problem. In general, heavy cutting seems to be favorable for regeneration. On south and west slopes, some shade is desirable. Artificial regeneration by planting and seeding should be tried on an experimental basis.

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Listed below are the timber sale cases which were reviewed on the ground and in the office in connection with this study. The writer worked on sales dated 1940 or later and was the officer in charge of sales dated 1944 and later. Size of sale is indicated in parenthesis.

Albertson, William;	Case of 1-21-36	Sawlogs (40 M.)	Magpie
	Case of 3-17-36	Sawlogs (37 M.)	"
	Case of 4-9-36	Sawlogs (32 M.)	"
Campbell, Jess E.;	Case of 1-5-44	Sawlogs (150 M.)	Park Gulch
	Case of 11-7-45	Sawlogs (150 M.)	" "
Baum, J. R.;	Case of 5-30-37	Sawlogs (50 M.)	" "
Dobler, William;	Case of 5-22-39	Sawlogs (100 M.)	Beartrap
	Case of 7-26-39	Sawlogs (50 M.)	"
	Case of 3-25-38	Sawlogs (25 M.)	Magpie
	Case of 8-11-39	Sawlogs (50 M.)	Beartrap
	Case of 8-12-39	Sawlogs (25 M.)	"
	Case of 11-1-39	Sawlogs (200 M.)	Vigilante
	Case of 11-30-39	Sawlogs (25 M.)	Beartrap
	Case of 4-25-40	Sawlogs (50 M.)	Vigilante
	Case of 5-25-40	Sawlogs (50 M.)	"
	Case of 6-17-40	Sawlogs (50 M.)	Trout Cr.
	Case of 7-24-40	Sawlogs (50 M.)	" "
	Case of 7-11-40	Sawlogs (527 M.)	Goodman
	Case of 10-6-42	Sawlogs (50 M.)	Trout Cr.
Dobler & Smith;	Case of 6-15-38	Sawlogs (56 M.)	Magpie
	Case of 8-1-38	Sawlogs (50 M.)	"
Dobler & Norseth;	Case of 1-10-43	Sawlogs (200 M.)	Trout Cr.
	Case of 1-8-44	Sawlogs (136 M.)	" "
Dobler, William;	Case of 9-30-46	Sawlogs (500 M.)	" "
	Case of 2-8-48	Sawlogs (150 M.)	" "
Gehring, Clifford D.;	Case of 6-7-46	Sawlogs (212 M.)	Hellgate
	Case of 2-13-47	Sawlogs (33 M.)	Hellgate
	Case of 3-3-47	Sawlogs (400 M.)	"
Hart, Paul & Geo.;	Case of 4-29-46	Poles, Sawlogs & Pulp (3,600 M.) includes (1,400 M D-f.) Magpie Gulch.	
Hysell, Floyd C.;	Case of 12-20-46	Sawlogs (300 M.)	Spring Gul.
	Case of 1-26-48	Sawlogs (950 M.)	" "

Casey Mining & Equipment Co.;	Case of 6-24-47	(2,800 M) Indian Cr.
Smith, Ben T.;	Case of 12-7-45	Sawlogs (100 M.) includes Sweat Gulch

B. Private Land Cases

Slash disposal work on the following cases was done by the Forest Service. Operations were reviewed and studied in connection with this paper.

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Norseth, Trygve;	Case of 12-29-45	Sawlogs (1,750 M.)	" "

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S-PLANS-Helena Indian Creek & Fantail 1943, (1,000 M D.F.)
J. R. Jansson, Chief of Party

Spring Gulch 1944 (3,300 M D.F.)
J. R. Jansson, Chief of Party

Magpie Gulch 1945 (26,000 M total 11,000 D.F.)
Jack Allen, Chief of Party

Trout Creek Survey 1946 (1,000 M)
L. R. Olsen, Chief of Party

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J. R. Jansson, Chief of Party

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U. S. FOREST SERVICE SITE CLASSIFICATION TABLE

Total age years	Douglas-fir Site Class VI	V	IV	III	II	I
	Total height in feet					
20		17	26	34	44	49
30		28	43	57	72	85
40	(No	38	57	76	94	111
50	minimum	45	68	89	110	131
60	height for	51	76	100	124	148
70	Site VI)	56	82	108	134	160
80		60	87	115	142	170
90		63	91	120	150	179
100		66	95	125	156	186
110		68	98	129	160	191
120		70	101	132	165	196
130		72	104	135	168	200
140		74	105	138	171	204
150		75	107	140	174	207
160		76	109	142	176	210
170		77	110	144	178	213
180		78	112	146	180	216
190		79	113	147	182	218
200		79	114	149	184	220
220		80	116	151	187	224
240		81	117	154	190	227
260		82	119	156	193	230
280		83	120	158	195	233
300		83	121	160	197	235
320		84	122	161	200	237
340		84	124	162	201	240
360		85	125	164	203	243
380		85	125	165	205	245
400						
	Approximate height of mature dominant trees in merchantable logs					
	1-2	3-4	5-7	8-10	11-12	13-15